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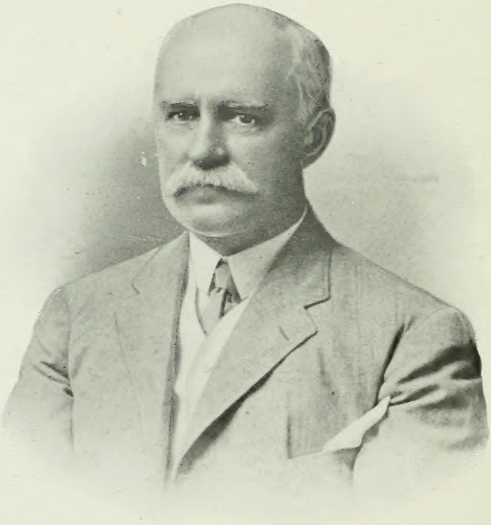

Dr. WILLIAM P. MASON, President

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OF THE

TWENTY-NINTH ANNUAL CONVENTION

OF THE

AMERICAN WATER WORKS ASSOCIATION

HELD AT

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THE VALUATION OF WATER POWER AND THE ESTIMATION OF STREAM DIVERSION DAMAGES

ROBERT E. HORTON

FUNDAMENTAL LEGAL PRINCIPLES

Accepted custom and legal precedent have established the following principles:

1. A riparian owner is entitled to have a stream flow at his premises substantially undiminished in volume or fall, unimpaired in quality and with nearly its natural regimen or order of rise and fall.
2. If a diversion from the stream is made, the measure of damages is not the value of the part taken *per se* but is the difference between the fair market value of the whole property and the value of what remains after the taking.

Many water power rights are not derived directly from the ownership of riparian rights in the ordinary sense of the word. An owner of water rights on a hydraulic canal may not have any direct fee in the bed or bank of the stream, but if he has riparian frontage he may acquire a much greater fall from the hydraulic canal than exists along his own ripus. He must have, however, in common with others, access to the stream at least at two points, at one of which the water is taken and at the other returned to the stream. A clear legal title to such secondary ownership to a part of the riparian rights concentrated by a dam can be derived only through predecessors in title who either owned or acquired all of the riparian rights affected. A grant of water power rights on a hydraulic canal may be made by an original riparian owner without surrendering all his incidental riparian privileges, such, for example, as the right to keep the water up to a certain level for navigation purposes. An owner on a hydraulic canal may or may not be entitled to the same indemnities for diversion as a riparian owner, but in so far as he is entitled to indemnity for diversion, the methods of determining the amount of damage are substantially the same as in the case of an ordinary riparian owner.

THE EFFECT OF DIVIDING A WATER POWER

The value of a water power per horsepower usually increases as the size of the power increases. If the power is divided the sum of the values of the two parts taken separately will usually be less than the value of the entire power as a unit. The difference in the aggregate values will usually decrease if the size of one of the parts is relatively small. From the above it is evident that the difference in value of a power before and after a part is taken may be greater than the value of the part taken itself, for water power purposes. The value of the remainder for power purposes may in some cases be substantially destroyed by the taking away of a part. For example, a water privilege with 10 foot fall may offer a profit yielding mill site, but if deprived by backwater of one-half the fall it may become worthless for development, or, if developed, the turbines would be ill-suited to the new conditions, the speed would be changed and auxiliary power required, so that if reconstructed the added cost of the new plant might make the production of power unprofitable as compared with other available sources.

Similarly a variable stream with 100 mean available horsepower and a minimum of 20 horsepower may become of very little value for steady use if 20 continuous horsepower is taken away. These are extreme cases intended for illustrative purposes only. The above discussion explains the necessity, in order to secure justice, that a different rule of damages should be used when a thing is taken in part from that used when it is taken entire. In the latter case the damages are measured by the fair market value of the thing taken. In the former case the measure of damage is the difference in the fair market value of the entire thing and of the part not taken. The two rules approach identity as the part taken approaches the entire property in magnitude.

FAIR MARKET VALUE

The fair market value should be understood as being the price accepted between an owner willing to sell and a purchaser willing to buy at a fair price, and at a sale that is not forced nor governed by circumstances other than the value of the property by itself.

The claimant for diversion damages will demand the fair market value for the best use to which the property can ordinarily be put, whether heretofore used in that or in some other manner.

WHAT CONSTITUTES A MARKET

The right to use the flow and fall of a stream for the generation of mechanical power is an easement appurtenant to the abutting land; in other words, whatever right can be acquired by an individual to use water for power is acquired as an incident to real estate.

As regards undeveloped power at least, it appears to me that the definition of a market and the determination of the value is primarily related to the same things in relation to land.

Considering water as real estate, there is a difference in the significance of the term "market" from the usage of the same term as applied to eggs, potatoes or electric current. In case of real estate the fact that it is used for a particular purpose in a particular locality is *prima facie* evidence that there is a market for that purpose, although there may be little or no evidence of sales or transfers. Considering water power as a marketable commodity in the same sense as eggs, potatoes or electrical current, as is frequently done in valuation cases, it is necessary to prove that there is an active demand for power and that sales can be made.

This has a bearing in discussing the different methods of valuing water power in what follows:

INDIRECT DAMAGES

When an owner is dispossessed by eminent domain he cannot be considered as "willing to sell," and if unwilling to sell he may be discommoded by being forced to do so. Justice apparently demands that the welfare and fortune of a cliamant shall be left unimpaired. The owner of a water power often considers it of more value to him for use in an established business than it would bring in an open market. As a rule the courts require the value of a water power itself distinct from the business in which it is used, especially if a part only of the water power is being taken, leaving the business otherwise unimpaired. If, however, as is often the case, the value of the power taken does not of itself represent the full measure of injury of the claimant, additional indirect damages may be awarded. Unless provision is made to indemnify the claimant for inconvenience and loss of profits, he will, it is evident, be inclined, in order to secure what he believes to be justice to himself, to charge to the water power account all the incidental damages which he has suffered.

RELATION OF A WATER POWER TO A BUSINESS

So-called water power valuations are sometimes based on the capitalized profits of a manufacturing plant using power. Such valuations may be necessary where an established plant is incapacitated, but they should be clearly understood as representing the value of the plant and business, and not merely that of the water power. In such estimates there are presumed business ability, knowledge of manufacture, and an investment greater than is necessary for the mere production and sale of water power. As Frizell remarks. "The owner of a basket of eggs is entitled to their value as eggs, not to the value of the chickens, which would, under suitable conditions, have been produced from them." In valuing a water power used in an established business care should be taken to credit to the water power only such a part of the aggregate profits as it actually produces, and vice versa. Suppose, for example, the investment in a water power and in a business it supplies are equal. If, now, the business yields 50 per cent return on the total investment, but power can be obtained in the open market at a price that leaves only a margin of 10 per cent on the investment for the power actually used, then it would be an error to assume a profit of 50 per cent each on the power and business, the actual profit being 10 per cent on the power investment and 90 per cent on the business investment. A similar error has, however, been made in water power valuations where it is assumed that the power is transmitted and sold at retail in the form of electric current. The sale of electric current is a business involving organization and management, and is subect to hazards, such as the uncertain tenure of franchises, waste and leakage, and collection losses not incidental to water power. It is often necessary in the valuation of water power to consider that it is transmitted electrically and sold in the open market. In such cases the capitalization rate should be increased to cover the extra hazard and the power should, if possible, be considered as sold in one block. It is the writer's usual practice in valuations *to consider the power disposed of in the simplest form possible, consistent with its best utilization.*

USE TO BE MADE OF POWER

In estimating the cost of development it is usually necessary to assume that some particular use is made of the power. This should be the best use to which it can ordinarily be put. The engineer may assume for purposes of valuation that the power is used for wood pulp grinding, flour milling, lumber, mineral or textile industry or for electric transmission, or any other use, providing there is present or prospective demand for power for that use in the locality. In making valuations where the power is used by its owner it is generally best to consider the power as sold to the business at a fair market price, and the power should be preferably in the form of water under a head, or mechanical horsepower on a turbine shaft, excepting in cases where electrical transmission is necessary.

ACTUAL, PROSPECTIVE OR POTENTIAL, AND SPECULATIVE USE

There is a wide range of conditions between a water power in actual use in a paying business in an established community, undeveloped water power in or near the same community, and a water power in a region remote from industry and civilization. The difference in value of power due to its location has been a stumbling block in many cases.

Water power may be compared to eggs, potatoes or other perishable commodities which if not used are wasted. Their value depends upon supply and demand and upon the cost of transportation from the source of production to the center of consumption, or, in other words, upon market facilities. Consider, for example, three water powers of similar physical characteristics equally feasible of development and located as described. The value of the power in actual use is controlled, with such qualifications as are elsewhere discussed, by the market value of whatever form of power rules the local power market. Its value to the user is measured, subject to the qualifications mentioned, by the difference between the capitalized cost of production of a water power and the capitalized cost of an equal amount of equally good and convenient power of whatever form controls the price and rules the local market. The value of the second or undeveloped power in the same locality may be similarly estimated, but if so, a different capitalization rate should be used because the use of the power is *prospective* and not actual. Courts usually allow for a reasonable prospective use or profit therefrom. It would be considered that there was reasonable prospective use for a power on a stream where similar powers are in successful use.

There is no immediate demand for the third power considered, and unless there is reasonable likelihood that it will repay development in the not distant future, its value may be considered as *speculative.* Other classes of powers, the value of which can only be considered as speculative, are those which, owing to their great variability, small flow, slight fall or other unfavorable physical characteristics, have not usually paid when developed. In this class also belong numerous other small powers in the vicinity of, or within reach of electrical transmission from large sources of cheap power such as, for example, water falls on great streams, or regions abounding in cheap coal of natural gas.

THE FORM OF POWER WHICH RULES THE MARKET

There are different grades and varieties of power, and in a given locality the market is often ruled by one kind of power practically to the exclusion of other kinds. The ruling variety of power is usually that which can be most easily and cheaply obtained in sufficient quantities. In communities where water power rules the market the cost of steam power has little relation to the value of water power in actual sales or transfers. Steam power may be extensively used in established plants, or for auxiliary power, or for purposes other than power, but no one desiring power for purposes for which water power could be used would think of purchasing steam power if water power could be obtained more cheaply. If there were ten similar manufacturing plants in a town and only one of them could be supplied with water power and the other nine all had steam engines, then we should say the local market was ruled by steam power. On the other hand, if nine of the plants had water power and there was enough water power available to supply all the plants, then we should say that water power ruled the local market.

In northern and western New York there are many water powers which were developed by the early settlers. With the decline of the lumber, tannery and flour milling industries these powers fell into disuse. Many of them have been redeveloped for wood pulp manufacture. This use also will probably decline in course of time. Thus we see that the local value of water power advances and decreases with the development and migration of industries. Many of the powers referred to are within reach of electric transmission from the great power centers of Niagara Falls and the St. Lawrence river. Power can be brought to the mills from these sources more cheaply than it can be developed *in situ*. The power market over a large district is controlled by electrically transmitted power. Competition with the sale of this form of power rather than with steam or other forms should be considered in estimating the damage to a local power in such localities by virtue of diversion of water. In other regions power may be produced from local coal deposits or from natural gas so cheaply as to preclude the present development of the water power resources. The writer wishes to make it clear that the form of power which rules the market in a given locality is an important element to be considered in arriving at the value of water power in that locality.

THE PRESENT WORTH OF AN UNDEVELOPED POWER

There are many fine water powers located so remote from civilization that their present development would not be profitable. Many of these powers are located in regions abounding with timber, mineral wealth or rich agricultural lands and are in the line of advance in industrial development. Such powers undoubtedly have a value as holdings which will increase from year to year. In such cases the writer has estimated the value of a water power as the present worth of the sum for which it could be sold at some future time when, according to a reasonable prognostic of industrial progress in the locality, it will become marketable. The same method may be applied to the case of determining the value of an inferior water power in a region where the market is controlled by some form of power that is at present cheap, but which may in time become fully utilized or exhaused. In order to determine the present value of a power for which there is no immediate need of development an estimate may be made of the probable return which it would yield if marketable at present, and the present worth of the capitalized value at the end of a period of years is assumed as the present value of the power. The capitalization rate should be high for the reason that in addition to the usual risks and uncertainties there is the possibility that before development becomes feasible inventions will be made that will change the customary forms of energy and make existing types of prime movers obsolete.

If C is the capitalized value which it is assumed the power will have at the end of N years, and P is the present worth of this sum, or the present value of the power, the current rate of interest plus taxes expressed decimally being R, then we have

$$P = \frac{C}{(1 + R)^N}$$

For example, it is estimated that industrial conditions will justify the development of a remote water power within 20 or 30 years, say 25 years as an average, and that this power at the ruling market rate would have a capitalized value of $30,000. If $R = 0.05$ we have from the above formula, solving by logarithms,

$$\begin{array}{rlll}
 & \text{Log } C & = & 4.4771213 \\
 & \text{Log } (1 + R) & = & 0.0211893 \\
N & \text{Log } (1 + R) & = & 0.5297325 \\
 & \text{Log } P & = & 3.9473888 \\
 & P & = & \$8859.10
\end{array}$$

Cases also arise where it is necessary to determine the value of developed water powers which will in the course of time become valueless for their present use owing to the exhaustion of raw material. There are numerous such powers in use to drive saw mills and wood pulp mills in regions where timber is being rapidly exhausted.

AUXILIARY POWER

A variable water power may be often enhanced in value by being operated in conjunction with an auxiliary plant. This may be a steam power plant, but gas, gasolene and oil engines are well adapted for intermittent auxiliary service in some cases. The use of auxiliary power is a common feature of development. A claimant is apparently entitled to base his valuation on the best use of a power and hence his expert may consider auxiliary power as an element affecting the value, although the courts have sometimes excluded evidence in which the use of auxiliary power was taken into account directly. Profits arising from steam or other auxiliary power *per se* apparently should not be credited to the water power in arriving at its value, when those profits might be obtained quite independently of the water power.

COMBINED WATER POWERS

Since the advent of electric transmission it has become possible to develop two or more powers by separate plants run in parallel and to transmit their combined output to market through a single line. In this way it may be profitable to transmit to a distance the combined output of several adjacent powers where the cost of right of way and transmission line would make a similar use of any single one of the powers unfeasible. Any one of a series of powers adapted to this use may have a holding value greater than its value if individually developed. Under the usual court rules the owner of such a power cannot realize on this holding value in condemnation proceedings unless he actually owns all of the water power. Furthermore the owner of a water power that could be increased in capacity or value by the purchase of adjoining property cannot presume to acquire that property and base his value thereon as if he already owned it, but an expert on value apparently may consider the possibilty of purchasing adjoining real estate as one of the physical conditions surrounding the property, just as the possible utilization of adjacent lands by himself or others may properly be considered by one intending to purchase a factory site.

AN EFFICIENT DEVELOPMENT IS USUALLY ASSUMED

Whatever may be the condition of actual development of a water power, the most efficient usual development should be considered in its valuation. The owner of a power is entitled to this assumption and furthermore, if his property is not efficiently developed and is sold, it will as a rule be purchased with a view to efficient utilization. Where a property is already well improved its value as it stands will be required. Obviously an owner cannot realize twice on his property, once for its present use and again for some prospective use. He may, however, realize on the larger of these valuations and this will usually be the former if moderately good, because the value of a "going concern" renders the prospective uses subject to a higher rate of capitalization.

CASES TO BE CONSIDERED

An engineer will meet with a great diversity of conditions in the valuation of power. He will be required to appraise complete water powers developed, partially developed and undeveloped. All these classes of power will be found in localities where there are good power markets, where markets can only be reached by transmission and where markets are limited and uncertain. He will be required to appraise water privileges at dams where each owner controls a specified permanent flow, or an irregular surplus flow, or both. He must also appraise the damage due to diversion under various conditions, as, for example, the diversion of a specified permanent flow, the diversion of surplus flow or the diversion of a certain total annual quantity to be taken irregularly as to time and rate. The valuation of a complete water power and the valuation of a part of a power destroyed by diversion or back water, or of the remainder after a part is so taken, have often been treated as if bearing no relation to each other. So far as possible certain general principles which underlie the valuation of all water powers, whether complete or taken in part, should be applied in the appraisal of all cases.

METHODS OF ESTIMATING DIVERSION DAMAGES

The following list includes a number of methods that have been heretofore used in arriving at the amount of damage resulting from the taking of water power as a whole or in part:

1. Pro rata payment per marketable horsepower.
2. Direct steam substitution.
3. Auxiliary steam substitution.
4. Valuation by the real estate method.
5. The method of capitalized savings.

PRO RATA PAYMENTS

This method is based on the assumptions:

1. That a horsepower is a commercial, marketable commodity and that one horsepower is worth as much as another that is equally good in the same locality.

2. It is assumed that the indemnity should be equal to the market value of the number of marketable horsepowers taken away if sold outright. Regarding this method it may be said that the market value of a horsepower considered as a merchantable commodity should be determined by comparison with the same kind of power. Even where water power rules the market a horsepower of steam power may be sold at a higher price than water power, because it is, or is assumed to be, better for some purposes. In the same way sweet potatoes are worth more per bushel than Irish potatoes even though the prevailing market is for the latter.

This method does not conform to the fundamental rule of damages from a real estate view point except in a case where a water privilege is taken without other real estate. For example, if a man owns a certain number of mill powers on an hydraulic canal which by stipulation or otherwise could be used at various locations, then he might sell some of these mill powers not incident to any other real estate and the method of arriving at value above considered would probably be applicable.

DIRECT STEAM SUBSTITUTION

Where this method is used indemnity is measured by capitalizing at some assumed rate the cost of construction, and maintenance in perpetuity, of a steam plant capable of supplying as much power as is diverted. The writer would primarily limit the use of this method to cases where steam power rules the market or is the most available substitute for water power. Essentially the same method may be used where electricity, gas, oil or other forms of substituted power are considered. Direct steam substitution, involving as it does the assumption that a new power plant is purchased and perpetually maintained, cannot in the writer's opinion be considered as an entirely satisfactory measure of damages for the taking of an entire water power, and is even less satisfactory in arriving at the value of a small diversion. The cost of steam power in small units is relatively large and higher than for large plants. The capitalized value of a small steam plant will, if sold and invested, often yield a much larger annual return than will the sale of water power equal to the capacity of the plant. Only by chance would the two yield equal returns. Even in localities where water power is abundant and rules the market there is nearly always more or less steam power in use, even though it is costing much more than water power would cost. Furthermore, in such localities water power is commonly sold at a fraction of the cost of producing steam power, and if water power is sufficiently abundant, the fact that the cost of steam power is excessive, does not materially affect the value of water power even in a region where coal is very costly. If there was enough water power power to supply the market the natural rental price of water would certainly be very much less than the cost of steam power, although there might be no actual competition. The danger of competition being developed, exists, however, in such a case. On the other hand, with coal costing $10 to $20 per ton, an insistent demand for power and insufficient supply of water power to meet this demand, the value of water power would be very great and would with certain qualifications be measured by the cost of steam substitution. This matter has often been a stumbling block to lawyers and experts, one side claiming that steam substitution alone shows the proper measure of damage where water power is taken away and the other sde claiming that steam substitution leads to absurd values and that it would make a power remote from the market and remote from a coal supply much more valuable than a power located at a commercial center. The writer hopes that this paper may bring out discussion which will clear the atmosphere in this regard. My present view is that steam substitution is a useful method in certain cases, but that it is not an omnipotent universal rule for gauging the value of water power.

AUXILIARY STEAM SUBSTITUTION

This method presumes the existence of an auxiliary steam plant and the indemnity is measured by the capitalized cost of operating it at the increased capacity sufficient to furnish an additional amount of power equal to that taken. The merits and application of the auxiliary steam substitution method have been ably presented by Mr. Charles T. Main in his paper on "Computation of the Values of Water Powers and the Damages Caused by the Diversion of Water Used for Power."*

Apparently an expert could properly consider auxiliary steam substitution in valuing a developed power having auxiliary steam or an undeveloped power which if developed would be provided with steam auxiliary, as, for example, in a locality where the leading industries require steam for heating purposes or in conjunction with manufacturing. If a plant is provided with auxiliary steam and part of the water power is taken, the operation of the auxiliary power at increased capacity is the most natural and frequently the most economical and satisfactory remedy. In the case of a power situated where coal is very costly or little used or where water power developed without auxiliary steam rules the market the auxiliary steam basis of valuation is evidently open to objection.

THE ERROR OF SUBSTITUTION IN PERPETUITY

In estimating damages from the capitalized cost of steam substitution an allowance should be made for the time the plant is idle. In any business there may be shut-downs due to accidents, repairs, labor troubles, business depression, poor management or changes of business. An award made on the assumption that the power is used continuously in perpetuity, as is sometimes done, would evidently be excessive. In estimates of damage on a power substitution basis an efficient use of the sub-

* Journal of New England Water Works Assoc., Sept., 1907, pp. 240–247.

stituted power should always be assumed even though there is an existing auxiliary plant which is used in an inefficient manner. It would, of course, not be proper to place a premium upon water power by presuming an inefficient use of the competing form of power.

STEAM AND WATER POWER ARE NOT EQUIVALENT

Steam and water power are dissimilar in many ways. A steam plant can be moved from place to place and exhaust steam may be utilized for heating purposes or in manufacturing. The quantity of power generated can be regulated at will up to the capacity of the plant. A steam plant must have fuel and water of suitable quality. In a water power plant the output is ordinarily variable. The plant itself cannot be moved and in the absence of artificial storage the supply of power cannot be directly controlled. It is sometimes an advantage to have a plant located on a stream which yields water power in order to procure water for manufacturing purposes.

OTHER FORMS OF POWER REPLACEMENT

The form of substituted power heretofore considered has been steam power. Before the advent of electric transmission steam substitution was practically the only method of continuing an isolated mill in full operation after its water power had been taken or destroyed as a whole or in part. At the present time, however, electric power can be purchased in the open market in many localities, and in addition producer gas, gasoline, fuel oil and other forms of caloric engines can be utilized to make good the deficiency. What form of substituted power is to be considered in a given case will depend on cost and applicability. The owner of a water power cannot be compelled to have its value measured by comparison with some form of power which is as yet experimental or uncertain.

REAL ESTATE METHOD OF APPRAISAL

The writer has applied this method to valuations made with or without technical skill, but made chiefly without conscious mental operations or numerical calculations, by persons supposedly so familiar with the market value of water power properties as to be able to fix the value with only a general viewing and examination of the property, in much the same way that a real estate appraiser will estimate closely the value of a building lot. The value of a water power is the resultant of many factors, and it is evident that experience and trained judgment are necessary to give these their proper relative weights by any mental process, conscious or subconscious. Judgment and experience should in turn be combined with a knowledge of the price of water power properties as determined by actual sales. Under these conditions an appraisal by the real estate method may be of great value. It will serve as a check on a valuation calculated by scientific methods as described below and as an aid in selecting a proper capitalization rate. On the other hand such expressions as "an arbitrary opinion founded upon cultivated judgment resulting from long experience" are sometimes used by experts merely as a cloak for ignorance, and it should be borne in mind that no amount of experience, if not in some degree correlated to the local conditions, can be a sufficient basis for the local valuation. In general an engineer's experience on water power in one locality will serve as a guide in other localities, but it should always be borne in mind that each case of valuation requires treatment by itself, and that there are certain local factors which it is needful to know, a knowledge of which cannot possibly be acquired from experience elsewhere. A better qualification of a valuation would be "an opinion reached by careful judgment based on actual knowledge of the situation and on extensive experience and research here and elsewhere."

HOW WATER POWER IS USUALLY BOUGHT AND SOLD

When a water power is wanted with a view to development, the intending purchaser or his engineer makes an estimate of the cost of development and seeks to determine what return may be expected from the use of the water power. In many cases this determination is of the most general character and amounts simply to the assumption that other adjacent water powers, having operated profitably, this one would also. If results are favorable the intending purchaser proceeds and buys the water rights as cheaply as possible from the owner, whose price may or may not be based on any similar calculations or assumptions, but very likely is not. The prices paid for similar water powers vary over a wide range. The calculated valuation derived as hereafter described should agree closely with the average price paid in sales of similar powers if the estimate is properly made and a suitable rate of capitalization is used.

DIFFICULTY OF SECURING COMPETENT EVIDENCE OF SALES

The opposing attorney will as a rule ask the expert on value to state the extent of knowledge on which his testimony is based and will at the same time insist that he confine his statement (1) To water power he has bought or sold. (2) To transactions in which he acted as agent or engineer and knows personally of the full transaction. (3) To sales that have been made on the same stream or in the same locality at about the same period of time, and where the conditions were similar.

As compared with ordinary real estate transfers the sales of water powers are comparatively infrequent and the chance is small that any one engineer will be able to testify regarding any considerable number of sales conforming to all the above requirements. The engineer may, however, have learned the facts regarding a much larger number of sales of water power with which he was not directly connected, but which are similar to the case in hand. Such data is, however, usually counted as hearsay and not admitted as testimony. In the writer's opinion an expert may, as he frequently will do subconsciously, utilize such so-called hearsay knowledge in forming an opinion, although as a rule a court could not permit him to base direct calculations thereon. It is suggested that engineering experts should insist upon getting clearly before the court the difficulty of reliable water power appraisal and insist on being allowed to utilize all the available information.

CALCULATED VALUATION

Engineers are accustomed to make scientific calculations of the cost of development, output and probable return which may be expected from a water power, and to use these results as a basis of reaching value of the water rights. The data required for such estimates include a plan of economical development based on a physical survey, knowledge of the available water supply, its variability, etc., and a knowledge of the best and most proper use which can be made of the power, a study of the amount and character of power available, an estimate of the cost of its production and a consideration of the local market for power for the proposed use, the market price of power so used, and the contingencies and chance of business. In such a valuation the best use should be made of all the available information applicable to the case. If indemnity for diversion is required a second estimate, with conditions as pertaining after the diversion is made, will be necessary.

FORM OF CALCULATED VALUATION

The accompanying schedule shows a form used by the writer for the purpose of summarizing the calculations used in making a valuation of a water power in a region where steam power rules the market price, but where the use to be made of the power was such that it could be sold as hydraulic power on a turbine shaft and no auxiliary steam plant was required directly.

Certain terms have been used with the following meanings:

"Total investment" this is the value of real estate and water rights plus the construction cost for development.

"Gross annual return." This is the amount realized from sales of power or other sources.

"Net cost of production." This equals the operating charges not including interest on investment.

"Gross profit." This equals the difference between the above two items.

"Net profit." This is the gross profit less interest charges on the total investment, including both real estate and construction.

"Gross capitalization rate." This is the rate of interest on the total investment which would equal the gross profit.

"Net capitalization rate." This is the gross rate less the rate of interest on bonds equal to entire investment. It is also the rate of interest on the entire investment which would produce the net profit. The net profit is the yearly sum which may be set aside as reserve to meet contingencies, which may be applied to sinking fund, to ultimately pay for plant and real estate or which may be distributed as stock dvidends.

SUMMARY OF CALCULATED VALUATION FOR WATER POWER USED AT SITE WITH NO AUXILIARY

Summary of Cost of Construction

Dam and forebay (*b*)	$..........
Head gates (*c*)	$..........
Racks and ice booms (*c*)	$..........
Head race and wheel pits	$..........
Water wheels and steel beams, flumes and casings (*a*) (*c*)	$..........
Water wheel governors (*c*)	$..........
Tail race	$..........
Power house (*a*) (*d*)	$..........
Other items added as required	$..........
First total	$..........
Contingencies, per cent on above	$..........
Second total	$..........
Engineering, per cent on above	$..........
Interest on investment during construction and preceding operation	$..........
Interest and taxes on real estate to date of operation	$..........
Total outlay except real estate	$..........

Gross Annual Return

..............H. P. capacity, load factor..per cent..... average H. P. This @ $........per H. P. year =	....

Cost of Power Production

....men @ $.......per day ......days per year	$..........
.... " @ $....... " " ...... " " "	$..........
.... " @ $....... " " ...... " " "	$..........
Similar items to include superintendence, bookkeeping, ice removal, etc	$..........
Employers' liability insurance	$..........
Fire insurance on items marked (*a*) (buildings, machinery, etc.)	$..........
Taxes on $........* at ......per cent	$..........
Oil, waste and supplies per year	$..........
Depreciation on items marked (*b*) @....per cent	$..........
" " " " (*c*) @....per cent	$..........
" " " " (*d*) @....per cent	$..........

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* This sum should cover assessable valuation including real estate and water rights, the latter being provisionally estimated.

Current repairs	$..........
Heating and lighting power station	$..........
Incidentals, telephone, etc	$..........
Total annual cost of production	$..........
Gross profit	$..........
Same capitalized at x per cent gross rate = *permissible total investment*	$..........
Cost of construction	$..........
Difference = permissible cost of real estate and water rights	$..........

Balance

Gross profit as above	$..........
Interest on $........total investment at y per cent =	$..........

Net profit

Difference =	$..........
Return from net capitalization rate (x-y) per cent on entire investment (also equals net profit)	$..........

The form covers the usual items to be taken into account, but does not give the details. Before undertaking such valuation it is of fundamental importance to determine the most economical size of plant to install. In doing this it is necessary to take into account the available market, the regularity and variability of the power which can be produced and of the power which can be sold, the effect of pondage or irregular use by other parties, etc. Attention is called to the method of arriving at the value of a water power, *i.e., the capitalized value of the net annual profit less the cost of development. This is the price that a purchaser could afford to pay for the water rights and privileges and still be assured of a net annual profit equal to the net rate of capitalization on the entire investment, including both cost of development and price paid for water rights, the annual profit being subject to the risks and chances taken into account in selecting a capitalization rate.*

Calculated valuations are not infrequently made in which the capitalized gross profit itself is given as the value of the water power. This method appears to me erroneous for the reason that if such a price was actually paid for the undeveloped power, the average return on the entire sum invested including cost of water rights would be much less than the rate of capitalization. The assumed rate of capitalization in such an estimate is not therefore the actual rate that could be realized. In cases where the value of the water power has been estimated by capitalizing the gross profit, without charging to the operating account any interest on the value of the water rights, the excuse is sometimes made that the owner of a power whose rights are being taken away does not have to pay himself interest on the value of those rights. In view of the fact that such statements are made in all seriousness it seems worth while to illustrate the conditions in a simple manner. Consider, for example, the owner of an unimproved piece of farming land worth in the market $10,000. As long as the owner holds it unimproved it brings him in no return. He could sell it at any time for $10,000, which properly invested would yield, say, $500 annual return. It may be possible for him to improve the land himself by the expenditure of, say, an additional $10,000 and after so doing to realize a net annual return from the property of $2,000. Two thousand dollars is the interest at 5 per cent on $40,000. Considering the case parallel to the one described for water power it might appear that the owner would be justified in placing the value of the farm at $40,000, but supposing that the purchaser was to pay that sum for it, borrowing the money at 5 per cent, and in addition was to expend $10,000 for improvements, his total investment would be $50,000, the interest on which at 5 per cent would be $2500, whereas the gross annual profit would be as before, $2000, making a net annual loss on the whole investment of $500 and no profit whatever. Now suppose that he purchased the property at $10,000 unimproved. After improving same he could realize an annual return of $2000, out of which he must pay interest on the *total investment* amounting to $1000, leaving a net profit above interest of $1000 per year. Now it may be presumed that capital would not ordinarily be invested in such a proposition unless a net profit of about this amount could be assured in addition to the payment of interest. It follows that the value of the property is $10,000 unimproved, because if any greater sum was paid for it the net annual profit over and above interest would be less than that ordinarily required in such investments.

CAPITALIZATION RATE

In the calculated valuation the result may be profoundly modified by a slight change in assumed rate of capitalization. The following table illustrates the effect of capitalization rate:

GROSS CAPITALIZATION RATE. PER CENT.	COST OF DEVELOPMENT, EXCLUSIVE OF WATER RIGHTS, PER DOLLAR GROSS PROFIT.						
	0.50	1.00	2.00	4.00	6.00	8.00	10.00
3	32.83	32.33	31.33	29.33	27.33	25.33	23.33
5	19.50	19.00	18.00	16.00	14.00	12.00	10.00
7	13.79	13.29	12.29	10.29	8.29	6.29	4.29
8	12.00	11.50	10.50	8.50	6.50	4.50	2.50
10	9.50	9.00	8.00	6.00	4.00	2.00	0.00
12	7.83	7.33	6.33	4.33	2.33	0.33	
14	6.64	6.14	5.14	3.14	1.14		
16	5.75	5.25	4.25	2.25	0.25		
18	5.06	4.56	3.56	1.56			
20	4.50	4.00	3.00	1.00			

The figures in the body of the table show the value of the water rights per dollar net annual return, the cost of development for the same unit being as given in the column headings, and with capitalization rates as given in the left-hand column. The table is intended to be illustrative only, and not to fix the range of practical values.

It is the writer's practice to include depreciation, repairs and replacements in the cost of production of the power, so that the gross annual return referred to in the table is the difference between the receipts for power marketed and the cost of producing the power, not including interest on the cost of development nor the cost of the water rights. In other words the power plant would be maintained in substantially its original condition and would not be paid for unless a sinking fund was provided out of the net annual return. Aside from interest, the cost of producing the power for a given proposition is assumed to be the same whatever price was paid for water rights and development. As an illustration of the use of the table, consider a power costing $4 for development per dollar gross annual profit and $6 for water rights, making the total investment $10 per dollar gross annual profit. Such a power would of course pay 10 per cent on the total investment, as the table shows. If, on the other hand, the risks of business and other conditions were such that it was necessary to secure a 12 per cent return then a purchaser could only afford to pay $4.33 for the water rights. The gross annual profit has to take care of interest on the entire investment, dividends, surplus and contingency funds. If the gross annual profit does not exceed the rate of interest there will be nothing left for the other elements which are included in the gross capitalization factor. For example, in the case first above considered if the interest charged was 5 per cent there would remain a net profit of 5 per cent on the entire investment, including water rights. On the other hand if a higher price, say $16 per dollar gross annual profit, had been paid for the water rights, the interest charge on the entire investment would precisely equal the gross annual profit and there would be nothing left for dividends, surplus or sinking fund. An extension of the table would show a condition where any sum whatever, no matter how small, paid for bare water rights would reduce the gross annual profit below the interest charge and in such a case the water rights are absolutely worthless. This will most frequently occur where the cost of development is high. For example, if the cost of development was $10 per dollar gross annual profit and a 10 per cent gross capitalization was necessary, nothing whatever could be paid for the water rights, because if payment was made for water rights the total investment would not yield a 10 per cent gross annual profit. In the same case if a gross capitalization rate of 5 per cent was used, this rate could be realized on a total investment of $20, including $10 for bare water rights, but this would yield no dividends, surplus or sinking fund if the interest rate was 5 per cent. The table shows very pointedly the limitations both as to cost of development and cost of bare water rights which circumscribe conditions of legitimate investment in water power.

The full meaning of the gross capitalization rate is not always appreciated in water power estimates. It includes among other things a measure of the risks of the business and of the profit which one skilled in that business would expect to obtain in return for his investment and skill in management. Where the risks and uncertainties of success are large the capitalization rate should apparently be high. In a recent report of the Inland

Waterways Commission all of the water powers in the Ohio River basin were capitalized at 3 per cent and many of these powers are remote from civilization and are of questionable feasibility. Suppose, for example, that a power is developed on borrowed money. It must first pay interest on the bonds issued and in addition the manufacturer or promoter must be assured of a reasonable return for managing a business involving large capital. He must have pay for his time and trouble and a reasonable clear profit in addition. This must be sufficient to reasonably insure the bondholders against loss due to unusual phenomena of nature commonly called "acts of God," against loss from strikes, business depression, bad management, etc. If the business is an established one the loss from these causes may be judged from experience. If, however, the development is new the necessity of creating a market and establishing the business adds another contingency to the list, and in addition the more novel or untried the character of the development or of the use to which the power is to be put, the greater will be the uncertainty of profitable outcome, and hence the capitalization rate must be higher and the price paid for the bare water rights lower as a rule than for a project of assured success. In a calculated valuation of a water power the selection of the capitalization rate requires judgment and experience and each case must be considered by itself. As an element entering into selection of capitalization rate knowledge of the market price of water powers in actual sales and transfers seems to the writer to be of prime importance, because such knowledge, when compared with the estimated cost of development, gives a measure of the capitalization rate as utilized in actual experience in the locality. As a general guide only, illustrative of the ordinary range of conditions, the following schedule has been prepared:

		GROSS CAPITALIZATION RATE PER CENT.
1.	Developed powers used by the owners in profitable industries	5 to 7
2.	Same as (1) but power sold in industrial centers	5 to 8
3.	Same as (1) but isolated	6 to 10
4.	Undeveloped powers, physical conditions favorable, use by owner intended	6 to 10
5.	Same as (4) but power sold to an assured market	7 to 11

6.	Same as (4) but remote, capable however of use at site	8 to 12
7.	Same as (4) but requiring transmission and sale of power and development of business	10 to 14
8.	Same as (7) but power to be transmitted and used in an established business	8 to 12
9.	Undeveloped powers, physical or market conditions unfavorable but still within the range of immediate feasible development	12 to 20

It will be seen that two experts who agree as regards market conditions and cost of development might, by using different capitalization rates, arrive at valuations differing by 100 per cent or more. In other words, no matter how accurate or complete the calculations, *the final question of valuation resolves itself into the use of judgment.* A factor which may properly be included and considered in the capitalization rate and which is often neglected is the effect of variability on the value of a power. Considering two powers each capable of yielding the same average annual output with plants of the same capacity, now if the stream supplying one of the power plants was much more variable and torrential in character than that supplying the other plant, then the value of the former power for many purposes would be much less than the value of the latter power. In general it is the writer's practice to use a higher capitalization rate as the variability of the stream or of the power output increases, and the variation in capitalization depends in a large measure on the use to be made of the power, as there are certain industries in which a variable power can be used to nearly as good advantage as a steadier power.

CONCLUSIONS

1. The indemnity for the taking of a water power as a whole or in part is measured by the difference in market value before and after the taking. If the whole is taken the second value is nil and the rule reduces to the determination of the original market value.

2. Justice apparently demands that the amount of indemnity should be such that it will leave the owner (aside from business or indirect damages) substantially as well off as before the taking.

3. The considerations which may properly enter in deter-

mining the amount of indemnity must be selected for each case according to the conditions. Considerations of auxiliary power, steam substitution, the cost of producing power, the prices paid in sales of power properties, the utilization of pondage and storage, etc., may not be admitted as proper evidence in the first instance, but may be taken into account by the expert in forming his judgment.

4. In arriving at the valuation of a property it should be assumed that it is put to a use that is both feasible and customary in the locality and that conforms to the best utilization of the property. If there is a choice between methods, that which gives the largest valuation of the part taken, other things being equal, may properly be used, since the owner is presumably unwillingly dispossessed, and if he were selling of his own free will he could only be presumed to accept the best price obtainable in the locality, and such a price would, as a rule, be that realized for the best utilization of the property.

5. All valuations may ultimately be resolved into questions of judgment as a large factor. Elements of judgment may be introduced subconsciously or through the medium of a capitalization rate. Each case must be treated by itself to a certain extent, but a knowledge of the proper capitalization rate may be derived by the methods outlined.

The writer does not presume to have covered all phases of this many-sided subject fairly and completely, What has been given is largely the outgrowth of experience in a considerable number of water power litigations covering a wide variety of conditions. With further study and experience some of the opinions here expressed may be changed and some of the propositions are offered tentatively, with the hope that they will elicit ample discussion and bring forth statements of the experience of others.

SOME RESULTS OBTAINED BY THE APPLICATION OF HYPOCHLORITE OF LIME ON MECHANICAL AND SLOW SAND FILTERS AND THE METHOD OF CONTROLLING COAGULENT AND THE OPERATION OF THE ORIFICE BOXES

A. E. WALDEN

Experiments have for some time past been carried on in the laboratory of the Baltimore County Water and Electric Company, to determine, if possible, a means to reduce the amount of coagulent used, also to put out a sterile water. The results so far have been very satisfactory, inasmuch that both the alum and the wash water have been reduced.

The first move made was to carefully calibrate the orifice box scale and check the orifice control, so that for a given setting on the scale, an even drop in inches per hour in the coagulent tanks would be secured. The improvement along these lines indicated conclusively that the scales on the control should be cut in the field, unless tanks were set up and tested in the shop. The graduation of the scale on the orifice boxes should be such that one inch on the scale will represent one inch drop in the tanks, and a fractional part of an inch, a corresponding drop in the tanks. This should be carefully done throughout the entire scale.

The method of operating the orifice boxes is clearly shown by the tables, which are so constructed that the filter tender can tell at a glance the proper setting for the proper results, with given turbidity and alkalinity. The tables give the range, specific gravity, grains per gallon, proper setting, and number of grains for a given turbidity of both alum and hypochlorite, as well as the proper number of pounds of each chemical and the number of gallons of water for the first tank of solution.

The method of maintaining the strength of the solution is in the use of hydrometers having a Fahrenheit scale, and a specific gravity scale as follows: 1.000 to 1.060 and 1.060 to 1.120. Two hydrometers being required, these show at a glance if the strength is above or below normal by the change in specific gravity. Blue prints similar to the tables No. 1 and No. 2 are attached to each of the tanks in plain sight of the operator of the orifice boxes.

Where hypochlorite of lime is used, care should be taken to limit the amount used so that none will go through the beds and show in any way in the effluent. The hypochlorite solution should be mixed in small amounts, as it rapidly loses its germicidal properties if allowed to stand any great period of time.

The effect of the hypochlorite seems to hold for a period of two days after application to the sedimentation basin, and it then is necessary to apply the solution to the beds or canal every other day as noted hereafter.

The application in the canal, between the sedimentation basin and the mechanical filter beds, of 0.1 grain of hypochlorite of lime, and with the alum solution cut to 0.7 grain per gallon, and running the hypochlorite solution on the beds every other day, we have been turning out an absolutely sterile water; that is to say, 50 per cent of the samples taken from the effluent of the filters contained no bacteria whatever. The balance of the plates had 1 and 2 individual bacteria and it required about six days' growth to cultivate these.

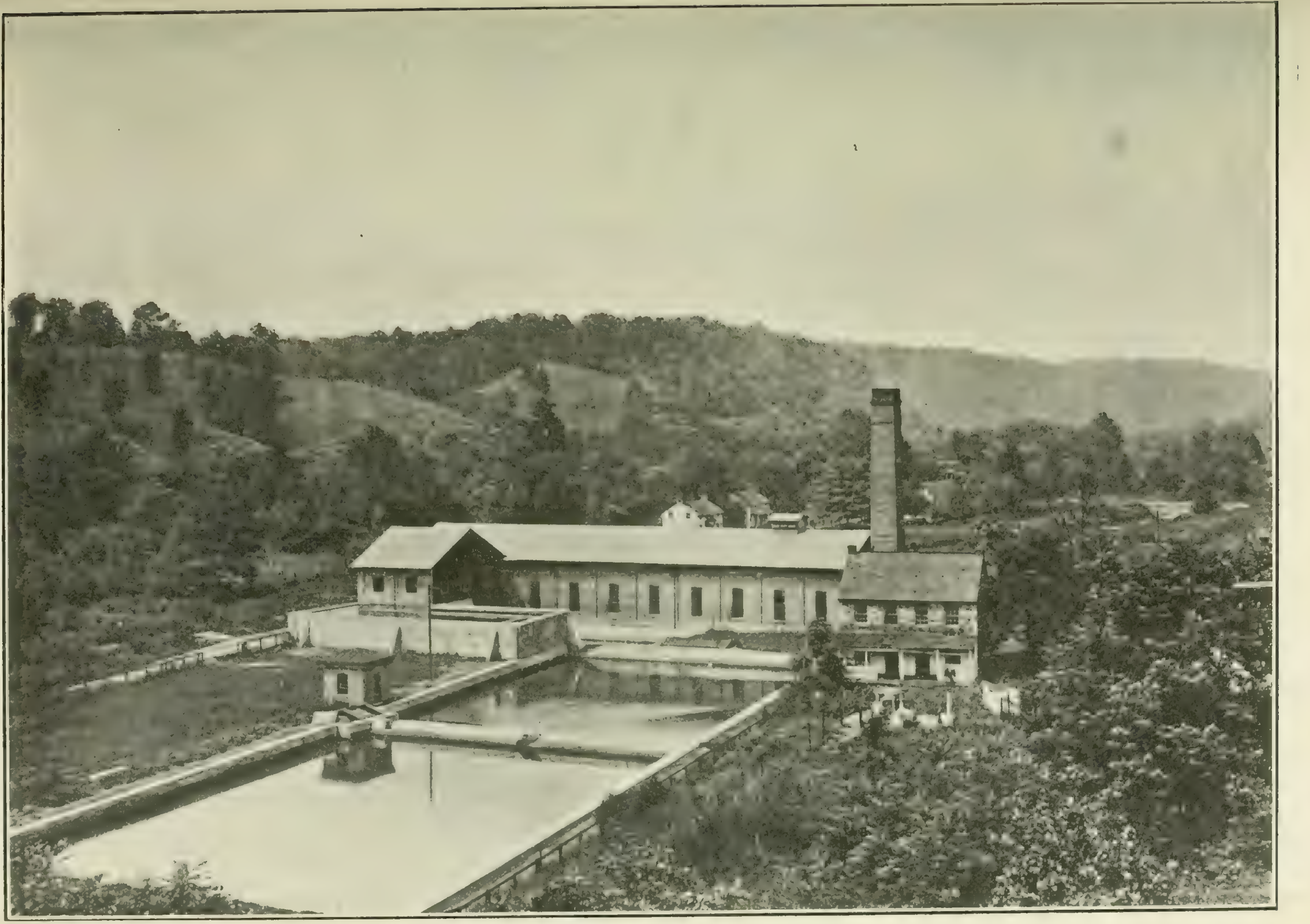
Additional experiments with the hypochlorite have practically convinced us that we can still further reduce both it and the alum and secure equally good results. We have noted that after using the hypochlorite there is a slight increase in chlorine, amounting to 0.25 to 0.5 parts per million, and that by the application of 0.1 grain of hypochlorite the bacteria have been reduced from 6000 to 16, with one sterile plate from the effluent, and one plate having 2 bacteria. The time required to make this reduction was 40 seconds. That is to say, a sample was taken before applying the hypochlorite which showed 6000 bacteria when applied; 40 seconds after application another sample was taken and the count reduced to 16 as shown by the plate. We attribute these results to the generation of nascent oxygen.

The use of hypochlorite of lime in this plant has reduced the amount of wash water necessary to clarify the beds, besides cutting down the alum bill. The wash-water reduction has been from 16,000 and 25,000 respectively, to 7,000 and 10,000 gallons, the filters running 30 hours when hypochlorite is used, as against 24 hours when alum alone is used.

With the results of the experiments as a guide, the slow sand filters are now being equipped with small concrete tanks and orifice boxes, as it has been shown that the filters will come into service more quickly, with a corresponding reduction in bacteria in the effluent with hypochlorite.

The various tables show how the experiments have been carried out on a practical scale, utilizing the regular filters for this purpose, the slow sand and mechanical filters being side by side as shown in cut.

The writer is indebted to the company's chemist, Mr. Shepard T. Powell, for the assistance and the careful manner in which these tests have been carried out, and the care given the work in the laboratory.



AVALON PLANT OF BALTIMORE COUNTY WATER AND ELECTRIC COMPANY

Table to be Used in the Application of Sulphate of Aluminium

Capacity of Tanks, 41.5 Gallons each
Grains of Aluminum Sulphate = 49,800
Charge of Main Supply Tank = 162 lbs. to 950 Gallons
Specific Gravity of Solution = 1.022° at 59° Fahr.
Graduation of Orifice = Drop of Solution in Inches in Tank per Hour.
Turbidity Expressed in Parts per Million—Alkalinity Expressed in Parts per Million
Rate of Filtration, 1,025,000 Gallons in 24 Hours—2 Filters

DROP OF SOLUTION IN INCHES PER HOUR	GRAINS OF ALUM DELIVERED PER HOUR, 1 FILTER IN OPERATION	TURBIDITY OF RAW WATER	GRAINS OF ALUM TO BE APPLIED TO FILTERS FOR CORRESPONDING TURBIDITY	GRAINS OF ALUM DELIVERED PER HOUR, 2 FILTERS IN OPERATION	GRAINS OF ALUM PER GALLON OF WATER FILTERED, 2 FILTERS	ALKALINITY REQUIRED FOR TOTAL ALUM USED	GRAINS ALUM TO BE APPLIED TO BASIN FOR CORRESPONDING TURBIDITY	GRAINS OF ALUM PER GALLON OF WATER FILTERED, 1 FILTER
1″	2075	0–10	0.00	2075	0.05	4.5	0.50	0.10
2″	4150	10–20	0.00	4150	0.10	5.4	0.60	0.20
3″	6225	20–30	0.00	6225	0.15	6.3	0.70	0.30
4″	8300	30–50	0.00	8300	0.20	7.2	0.80	0.40
5″	10375	50–75	0.10	10375	0.25	8.5	0.85	0.50
6″	12450	75–100	0.10	12450	0.30	9.0	0.90	0.60
7″	14525	100–150	0.10	14525	0.35	9.4	0.95	0.70
8″	16600	150–200	0.15	16600	0.40	10.3	1.00	0.80
9″	18675	200–300	0.15	18675	0.45	11.2	1.10	0.90
10″	20750	300–500	0.20	20750	0.50	12.6	1.20	1.00
11″	22825	500–750	0.20	22825	0.55	13.5	1.30	1.10
12″	24900	750–1000	0.30	24900	0.60	15.3	1.40	1.20
13″	26975	1000–1500	0.30	26975	0.65	16.2	1.50	1.30
14″	29050	1500–2000	0.40	29050	0.70	18.0	1.60	1.40
15″	31125	2000–3000	0.50	31125	0.75	20.2	1.75	1.50

Add columns 4 and 8 for total Alum
Boxes not to be used until Turbidity runs 50 to 75
Alkalinity must always exceed amount shown in Column 7
Add Water or Alum to bring Hydrometer up or down as required
Add Lime or Soda Ash if Alkalinity runs below that in Column 7

Table 2—To be Used in the Application of Hypochlorite of Lime

Capacity of Tank = 41.55 Gallons
Charge of 5 lbs. = 35000 Grains
Specific Gravity of the Solution = 1.024 at 59° Fahr.
Orifice Graduated in Inches
Rate of Filtration 1,025,000 Gallons in 24 Hours

DROP OF SOLUTION IN TANK IN INCHES PER HOUR	GRAINS OF HYPOCHLORITE DELIVERED PER HOUR	HYPOCHLORITE OF LIME	
		Grains of Lime per gallon of water filtered, 1 Filter	Grains of Lime per gallon of water filtered, 2 filters
1″	1371	0.06	0.03
2″	2742	0.12	0.06
3″	4113	0.19	0.09
4″	5484	0.25	0.12
5″	6855	0.32	0.16
6″	8221	0.38	0.19
7″	9597	0.44	0.22
8″	10961	0.51	0.25
9″	12331	0.57	0.28
10″	13710	0.64	0.32

Table 3, Showing Results Obtained by the Use of Hypochlorite of Lime

BACTERIA PER CC.					GRAINS PER GALLON										
RAW WATER.	BASIN TIME 40 SECONDS		FILTER NO. 1	FILTER NO. 2	ALUM		HYPOCHLORITE OF LIME	TURBIDITY		COLOR		ALKALINITY		CHLORINE	
	Before application of hypochlorite of lime.	After application of hypochlorite of lime			Basin	Filter	Basin	Raw	Filter	Raw	Filter	Raw	Filter	Raw	Filter
460	400	14	0	2	0.96	0.00	0.10	15	0.0	12	0	16.0	8.0	3.50	4.00
660	550	10	1	–	0.98	0.00	0.15	18	0.0	14	0	13.0	8.0	4.00	—
30,000	6000	16	0	2	0.98	0.12	0.10	200	0.0	30	0	17.0	7.0	3.50	4.00
2600	1350	8	0	0	0.86	0.10	0.10	80	0.0	28	0	12.0	6.0	4.00	4.25

Showing Results Obtained by the use of Alum Alone

	SEDIMENTATION BASIN.						NONE USED								
400	210	210	8	OUT OF SERVICE	0.86	0.15		15	0	15	0	15.0	11.0	4.00	4.00
620	330	330	9		0.96	0.00		15	0	12	0	12.0	6.0	4.00	4.00
500	330	330	6		0.96	0.00		12	0	12	0	12.0	5.0	3.50	3.50
520	390	390	20		0.96	0.00		12	0	10	0	10.0	3.0	4.00	4.00

Table 4—Bacterial Results Obtained by the Use of Hypochlorite of Lime

TIME OF APPLICATION	BACTERIA	GRAINS PER GAL. .11	GRAINS PER GAL. .22	GRAINS PER GAL. .33	GRAINS PER GAL. .49	TIME AFTER APPLICATION
0	500	10	6	8	8	5 min.
0	510	13	12	6	14	10 min.
0	550	6	10	9	6	15 min.

Table 5—Showing Effect of Adding Clay or Mud in the Mechanical Filters

TURBIDITY	RAW WATER COUNT	MECHANICAL FILTER NO. 1	SLOW SAND FILTER NO. 3	ALKALINITY	COAGULANT USED GRAINS PER GAL.
10	570	26	11	19	0.98
A-18	3100	12	14	22	0.98
20	980	98	15	22	1.10
A-28	3920	40	35	20	1.10
A-30	4480	4	12	19	1.10
8	820	87	8	22	1.10
A- 8	720	18	14	21	1.10

Counts lettered A show the effect of the addition of clay or mud.

Table 6—Showing the Effect of Ozone on Water

BACTERIA PER CC.			COLI		COLOR			TURBIDITY			OXYGEN REQUIRED		
Raw	Ozonized	Per cent removed	Raw	Ozonized	Raw	Ozonized	Per cent removed	Raw	Ozonized	Per cent removed	Raw	Ozonized	Per cent removed
2460	26	98.95	Present	Not Found	22	5	77.28	20	20	00.0	1.55	0.60	61.30
2800	12	99.58	"	" "	30	15	50.00	40	40	00.0	1.40	0.85	39.19
1100	5	99.55	"	" "	17	0	100.00	15	15	00.0	1.15	0.55	52.18
1270	6	99.53	"	" "	35	15	57.15	15	15	00.0	1.47	0.85	42.18
1200	0	100.00	"	" "	12	0	100.00	17	17	00.0	1.15	0.70	39.13
59000	680	98.85	"	" "	65	40	38.47	400	400	00.0	3.75	3.10	17.34

Results Obtained from Ozone Sterilizers

DATE	BACTERIA		B. COLI		REQUIRED OXYGEN		NITRATES		TURBIDITY		COLOR		CO_2	
	Raw	Ozone	Raw	Ozone	Raw	Ozone	Raw	Ozone	Raw	Ozone	Raw	Ozone	Raw	Ozone
Mar. 30.....	400	20	0/4	0/4	0.75	0.65	0.425	0.425	25	25	17.0	10.0	3.0	3.0
" 31.....	300	11	0/4	0/4	0.65	0.45			23	23	15.0	10.0	3.0	3.0
Apr. 2.....	480	23	0/4	0/4	0.80	0.55			23	23	15.0	8.0	4.0	4.0
" 5.....	320	7	0/4	0/4	0.90	0.60	0.450	0.450	18	18	18.0	8.0	3.0	3.0

Table 7—Bacterial Count after Washing

RAW WATER	BACTERIA PER CC.						TURBIDITY OF RAW WATER	COAGULANT IN GRAINS PER GALLON	
	Immediately after washing	5 Minutes after washing	10 Minutes after washing	20 Minutes after washing	30 Minutes after washing	60 Minutes after washing		Basin	Filters
8125	225	180	142	236	207	205	100	1.10	0.37
1200	228	206	223	115	110	73	45	0.98	0.10
675	240	305	215	135	150	70	20	0.98	0.00
340	900	390	225	152	95	82	15	0.86	0.00
20400	2550	725	290	500	150	135	3000	0.98	0.76
18000	240	100	50	34	75	67	3000	0.98	0.86
20400	250	100	88	15	19	26	3000	0.98	0.74
15000	185	120	11	9	14	11	3000	0.98	0.60
18000	130	160	33	52	15	16	3000	0.98	0.74

Table 8—Showing the Bacterial Efficiencies of the Slow Sand Filters and Mechanical Filters with Different Turbidities of the Raw Water

BACTERIA PER CC					TURBIDITY OF RAW WATER	COAGULANT USED
RAW WATER	MECH. FILTERS		SLOW SAND FILTERS			Mechanical Filters
	No. 1	No. 2	No. 3	No. 4		
630		36		6	12	0.73
930		29		8	10	0.73
410		38		6	10	0.73
420		32		5	8	0.73
1200		26		3	10	0.98
900		23		26	30	0.98
1020		17		31	40	0.98
1150		15		30	50	0.98
1000		14		30	50	0.98
860		13		25	50	0.98
940		8		24	60	0.98

Table 9—Showing the Germicidal Action of Chloride of Lime Which had been Kept Air Tight until Made up in Solution for Use

AMOUNT OF HYPOCHLORITE OF LIME USED	TIME ELAPSING BETWEEN APPLICATION OF LIME TO WATER AND PLATING OF SAMPLES			
	Immediately Treating	15 Min.	30 Min.	60 Min.
Control 00	560	620	710	810
.10 Grain per Gallon	14	8	11	12
.30 Grain per Gallon	8	6	6	9
.50 Grain per Gallon	4	9	9	9
1.00 Grain per Gallon	2	7	4	0

Table 10—Showing the Loss of Germicidal Action of Chloride of Lime Due to the Exposure of the Chemical to the Air Before Mixing in Solution

AMOUNT OF HYPOCHLORITE OF LIME USED	TIME ELAPSING BETWEEN APPLICATION OF LIME TO WATER AND PLATING OF SAMPLES			
	Immediately	15 Min.	30 Min.	60 Min.
Control 00	430	600	780	1260
.10 Grain per Gallon............	24	34	88	124
.30 Grain per Gallon............	50	45	85	90
.50 Grain per Gallon............	34	25	60	95
1.0 Grain per Gallon	14	19	45	60

Table 10-A—Showing Loss of Germicidal Action of Hypochlorite of Lime When the Solution Had Been Made up for Four Weeks.

AMOUNT OF HYPOCHLORITE OF LIME USED	TIME ELAPSING BETWEEN TREATING WATER AND THE PLATING OF SAMPLES			
	Immediately	15 Min.	30 Min.	60 Min.
Control 00........	330	670	980	825
.10 Grain per Gallon............	270	290	600	740
.30 Grain per Gallon............	350	370	510	510
.50 Grain per Gallon............	310	270	430	480
1.0 Grain per Gallon..............	210	200	200	300

Table 11—Table Showing the Result of the Application of Hypochlorite of Lime and the Apparent Effect Remaining for a Period of two Days, Lime Being again Admitted on the Third Day.

BACTERIA PER CC.					ALUM USED.		LIME	CHLORINE	
Raw	Basin	After Application of lime.	No. 1 Filter	No. 2 Filter	Basin	Filter	Basin	Raw	Filter Effluent
380	190	5	0	0	0.61	0.00	0.10	4.00	4.75
2500	700	10	2	0	0.98	0.00	0.10	4.00	4.50
820	400	5	0	0	0.86	0.00	0.10	5.00	6.00
470	320	3	0	0	0.86	0.00	0.10	4.50	5.00
460	210	1	0	0	0.48	0.00	0.10	3.75	5.00
2000	480	5	0	2	0.98	0.00	0.10	4.00	4.50
480	270	None 270	1	0	0.72	0.00	0.00	4.00	4.00
465	210	None 210	3	0	0.72	0.00	0.00	4.00	4.00

WASTE WATER SURVEY, CITY OF CHICAGO

T. C. PHILLIPS

For some years past the per capita consumption of the city of Chicago has been steadily increasing. The consumption in 1890 was 126 gallons daily per capita. During the following ten years the consumption steadily increased to 181 gallons per capita. This was a total increase of 55 gallons daily per capita or 5½ gallons daily per capita per annum for the period from 1890 to 1900. This rate of supply further increased from January 1900, to January 1907, to 204 gallons daily per capita. The supply in 1907 was based on a total daily pumpage of 450,000-000 gallons per day and a population of 2,225,000, taken from the U. S. Government Census for 1900.

In view of the above facts the need of curtailing the increasing consumption in Chicago is manifestly a most important one. Preliminary surveys were made in 1904 to obtain some reliable and accurate information regarding the high rate of consumption. These surveys were carried on for a period of six months, and a valuable report of the investigation was published in the City Engineer's Report for 1904. Further investigations were made in 1906, but no appreciable reduction of waste was made at this time.

In 1907 the city appropriated $25,000 for water survey work. A division of engineers was organized and the investigations were begun on a larger scale. The work was carried on under the supervision of the Water Pipe Extension Division of the Bureau of Engineering. All employed in this work were Civil Service men, and in consequence considerable time was required in certifying men and in organizing the field parties. The appropriation for this year did not provide for house to house inspectors, but some of this work was done, however. Seven districts were surveyed during the year, covering an area of 2916 acres, extending from Lake Michigan west to Halsted Street, and from Lake Street south to Twenty-second Street.

The waste water surveys were continued during 1908 and the territory was further extended north to Chicago Avenue, west to Halsted Street, and south to Thirty-first Street. This district lies in the older and more densely populated section of the city of Chicago, where building changes have been rapid. The investigations showed that the water supply for this section was excessive and that it was a very profitable one for the stoppage of waste and leakage.

An appropriation of $35,000 was made in 1908 for water surveys. Two field parties of house to house inspectors, numbering 22 men, were added, making an efficient force to carry on this work.

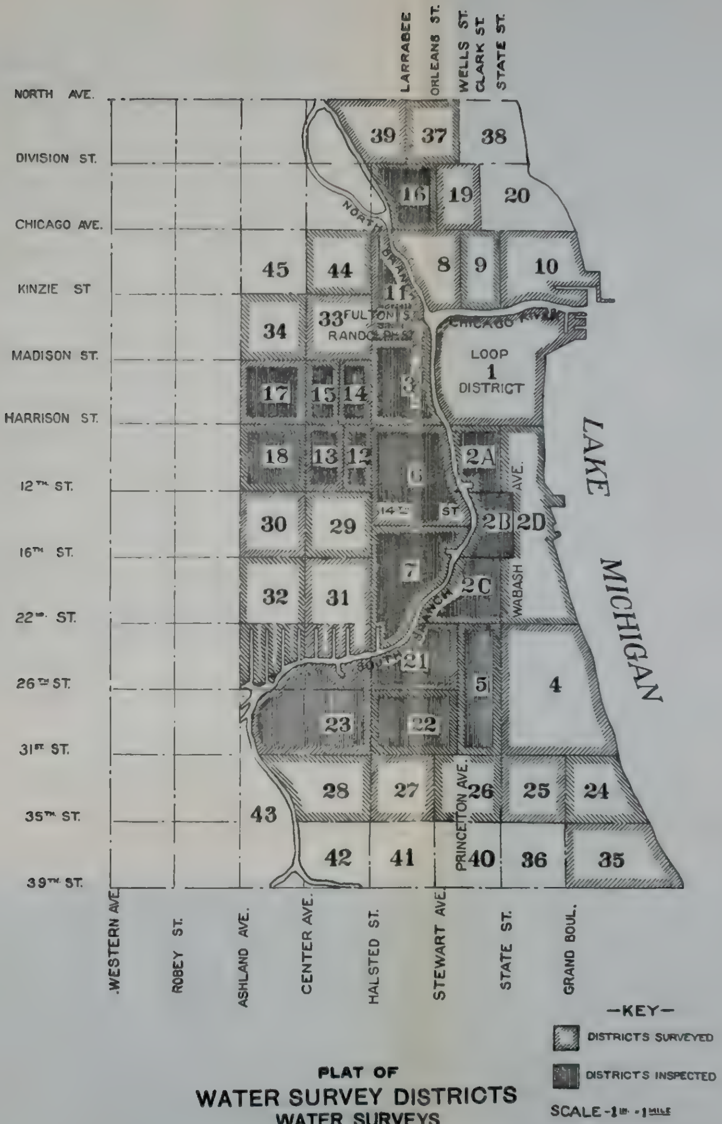
METHOD OF INVESTIGATION

The method of waste water investigation employed in Chicago on water survey work is the Deacon system, which was first used in England. The pitometer is the instrument used for measuring the water. It is a light, accurate, portable device that can be set up easily on the street anywhere, and, at the conclusion of the test, quickly moved to another location.

The districts surveyed varied in size from 75 to 300 acres, according to the character of the water consumption and the arrangement of the water mains feeding the section.

When the area to be surveyed was defined, the valves along the boundary of the district were closed tight, and a pitometer was set up on the supply main feeding the district. A continuous photographic record was made for a period of about seven days, from which the average daily consumption of the district was determined. A second test, called a subdivision, was made to localize the flow, when the night rate into the district was high or excessive.

The method of making a subdivision test is as follows: A pitometer was placed in operation as in measuring the water feeding a district. The district was then narrowed down in successive steps, by closing the interior valves and opening the boundary valves. The sections are cut off in this manner from the main district, until it is reduced to the smallest area. A simultaneous drop in the flow is indicated by the pitometer as each section of the district is eliminated. This drop in consump-



PLAT OF
WATER SURVEY DISTRICTS
WATER SURVEYS
1909

tion, or amount of decrease in the flow, is the volume of water required by the subdivision cut off. The location of the leakage and waste is thus determined, showing whether it is confined to one location or spread over the entire area of the district.

HOUSE TO HOUSE INSPECTION

An important feature of the Deacon system is the economy obtained in making house to house inspections. Only territory is inspected where the consumption is high. In most of the districts surveyed so far, an inspection was made over the entire area. In a few subdivisions, however, this was not necessary.

The house to house inspections were made by city plumbing inspectors, who were certified gradually as they were available from the Civil Service list. The full number of 22 inspectors was not placed in service until after September of 1908. This force of men was divided into two field parties, each under a competent and experienced chief inspector, who remained in the field and directed his men. Their hours are from 8:30 a.m. to 5:00 p.m. Daily reports were made by each inspector, and notices were sent to the owners where plumbing repairs were necessary. After these repairs were completed subsequent visits were made to ascertain if the repair work was satisfactorily done. Where the owners refused, or failed to make repairs after reasonable notice, the water was shut off. This was the exception rather than the rule, as in most instances the owner complied promptly with the first notice. In some instances the owner or agent made partial repairs, and only after receiving several notices and visits from an inspector was the work completely done. Faulty plumbing repairs by incompetent or unreliable plumbers were frequently encountered, but when it was learned that all repair work was reinspected by city plumbing inspectors, satisfactory repairs were made.

TABLE No. 2. *Summary of House to House Inspection Water Surveys, City of Chicago, 1908*

DISTRICT NUMBER	NUMBER OF SUBDIVISIONS IN DISTRICT	ACRES	NUMBER OF PLACES INSPECTED	LEAKY FIXTURES DISCOVERED					UNDERGROUND LEAKS	LEAKAGE—GALLONS PER DAY		
				Faucets	Closets	Baths	Miscl.	Total		Metered	Unmetered	Total
District in Englewood			36		8		2	10	10	3,240		3,240
55th St.			67	32	32		3	67	3	26,640	45,360	72,000
Parts of 2A†	†19	†113	†503	†170	†215		†29	†414	†71	†122,144	†141,916	†264,060
Parts of 2B	9	94	90	24	39		15	78	39	29,160	36,000	65,160
Parts of 2C	10	149	419	93	170		6	269	108	50,360	268,400	318,760
6	12	319	2,060	1,074	753	10	66	1,903	1,526	200,340	2,023,729	2,224,069
7	10	304	2,073	359	290	2	40	691	742	22,820	652,652	675,472
Part of 9—		125	185	47	102	1	5	155	60	5,990	75,148	81,138
12	8	70	787	293	297	6	25	621	406	30,122	301,712	331,834
13	7	90	1,011	293	434	23	51	801	439	2,952	223,833	226,785
14	6	80	684	186	351	23	37	597	285	13,124	188,996	202,120
15	5	80	727	148	336	28	28	540	198	5,112	204,116	209,228
17	6	160	1,294	339	597	17	51	1,004	230	12,572	403,470	416,042
21	9	164	798	150	171	8	14	343	445	456	141,888	142,344
22	9	215	1,421	239	447	3	24	713	741	6,996	253,326	260,322
23	10	370	1,587	261	343	6	26	636	673	6,240	287,670	293,910
		2,320	13,239	3,538	4,370	127	393	8,428	5,905	416,124	5,106,300	5,522,424

† = 1907 Figures—not added in total—

STATEMENT OF ESTIMATED COST OF SUPPLYING WATER TO CONSUMERS OF CHICAGO FOR THE YEAR 1907:

Expenditure for operation	$1,484,485.60
Expenditures for interest on bonds, certificates and judgments	183,694.85
Expenditures for repairs and renewals	751,768.34
Expenditures for refunds	22,174.18
	$2,442,122.97
Expenditures, total ordinary	$2,442,122.97
Sinking fund for water loan bonds	296,000.00
Net depreciation of water works, property and equipment over amount expended for repairs and renewals	845,028.14
Interest, net invested capital, assumed 3 per cent	1,236,626.68
	$4,819,777.79
Total gallons pumped during 1907	166,145,584,751
Cost per 1000 gallons	$0.02901

District No. 1

This is the business section of the city and is commonly called the Loop district. It is bounded by Lake Michigan, the Chicago River and Harrison Street, and has an area of 720 acres or 144 city blocks.

The supply for the Loop district was measured for nine consecutive days during September and October of 1908. The average daily rate of consumption was 17,543,000 gallons per day. The average daily metered rate of consumption based on the total supply of 1908 was 13,062,000 gallons per day. The minimum night rate of supply was 10,500,000 gallons per day, which is 57 per cent of the average daily rate.

The total annual revenue for metered water for this district amounted to $334,665 and the total frontage revenue to $8985. These figures show that the city receives one-half a cent per 1000 gallons for the unmetered supply in District No. 1, or approximately $9000 per annum for 4,500,000 gallons per day. The cost of this amount of water at three cents per 1000 gallons is $49,275 per annum.

A house to house inspection was not made on account of the contemplated construction of a subway in the down-town loop. There undoubtedly is a large underground leakage in this district, as the minimum night rate is 60 per cent of the average daily supply. Some of this loss is due no doubt to meter slippage. This, however, should be small during the minimum hours of the night.

District No. 2A

This district is covered with freight yards and freight houses. It has an area of 113 acres and a population of 4600.

The first survey of this section was made in July, 1907, when the daily supply was 4,030,000 gallons. The minimum night rate at this time was 3,700,000 gallons, or 91½ per cent of the average daily rate of supply. A test was made at night by subdividing the district into nineteen subdivisions, which showed a total night rate of 3,600,000 gallons per day.

A complete house to house inspection was made showing that the plumbing leakage was excessive throughout the district. After repairing the leaky fixtures further subdivision tests were made to determine the underground leakage. This resulted in still finding a high night rate over the entire area. A street having an unaccounted-for leakage of 325,000 gallons per day was selected, and the 12-inch main in the street was stripped for a distance of two blocks. This leakage was found wasting away through old, abandoned service pipes. One battered 1¼-inch lead service, which undoubtedly was running for a long time, was wasting 60,000 gallons per day. The pipe-joint leakage was small.

The cost of stripping these two blocks a distance of 1684 feet was $1908. This cost was high, as the work was done at the beginning of the freezing weather, in addition to removing the paving and a street car track. The saving at 2.9 cents per 1000 gallons amounted to $3440 per annum.

A total reduction of 1,430,000 gallons per day was made in this district, amounting to a total saving in revenue of $13,043 per annum at 2.9 cents per 1000 gallons.

The night rate of supply after reducing the consumption to 2,600,000 gallons per day was practically the same as the day rate, which indicates a high leakage remaining that could be saved by stripping the mains and abandoning all old services not in use.

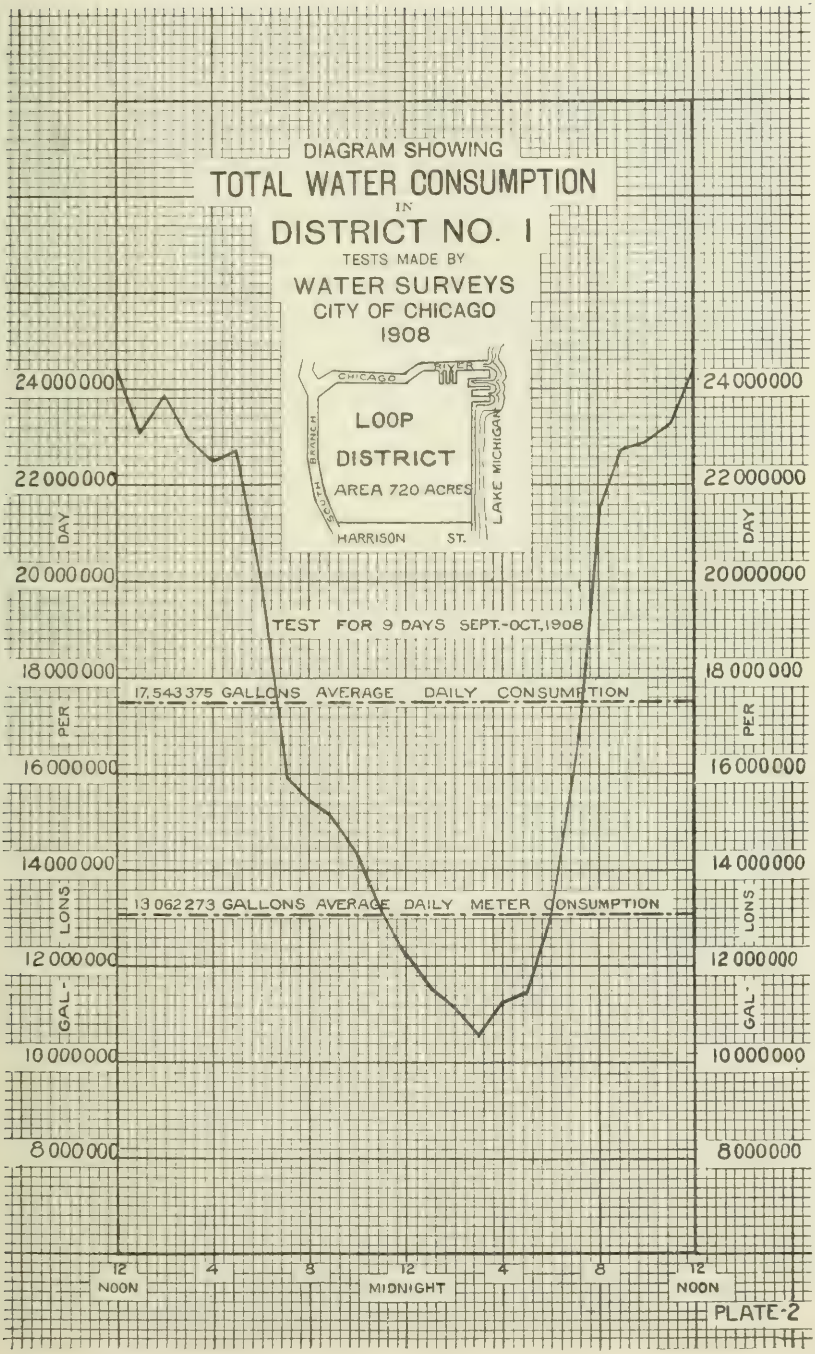


DIAGRAM SHOWING
TOTAL WATER CONSUMPTION
IN
DISTRICT NO. 1
TESTS MADE BY
WATER SURVEYS
CITY OF CHICAGO
1908
CHICAGO
RIVER
SOUTH BRANCH
LOOP
DISTRICT
AREA 720 ACRES
LAKE MICHIGAN
HARRISON ST.
TEST FOR 9 DAYS SEPT.-OCT. 1908
17,543,375 GALLONS AVERAGE DAILY CONSUMPTION
13,062,273 GALLONS AVERAGE DAILY METER CONSUMPTION
24 000 000
22 000 000
20 000 000
18 000 000
16 000 000
14 000 000
12 000 000
10 000 000
8 000 000
GAL-LONS PER DAY
12 NOON
4
8
12 MIDNIGHT
4
8
12 NOON

PLATE-2

District No. 2B

This district has an area of 94 acres and a population of about 600. It is covered with railroad yards and freight houses.

The total supply in this district was 1,620,000 gallons per day, with practically no decrease in consumption at night. The metered consumption amounted to 275,920 gallons per day.

A house to house inspection was made in subdivisions No. 6 and No. 8, which include State Street from Twelfth to Sixteenth Streets. Ninety places were inspected and 39 water-closets and 29 underground leaks inside premises were found. The underground leaks were discovered by use of the aquaphone. After making these repairs the leakage remaining in the street due to leaky joints and old service pipes amounted to 277,000 gallons per day. The records of the department show that this portion of State Street has been opened frequently to repair abandoned services.

The total underground leakage found in District No. 2B, by subdividing at night, was approximately 828,000 gallons per day. Practically all of this leakage could be eliminated by stripping the mains and abandoning old, unused service connections.

A second test was run for four days after making plumbing repairs and other corrections in the district, which showed that the district was using 1,292,000 gallons per day, or 328,000 gallons per day less than before the inspection. In this test the night rate was practically the same as the day rate, which indicates a high leakage remaining.

The annual metered revenue for this district was $7069.19 and the frontage revenue amounted to $991, or a rate of one-fifth of one cent per 1000 gallons.

The saving made by house to house inspection in the two subdivisions of this district, at 2.9 cents per 1000 gallons, amounted to $3481 per annum.

District No. 2C

This district is similar to districts No. 2A and No. 2B. It is covered with tracks and freight houses along the Chicago River front, with the exception that it has a larger number of low-

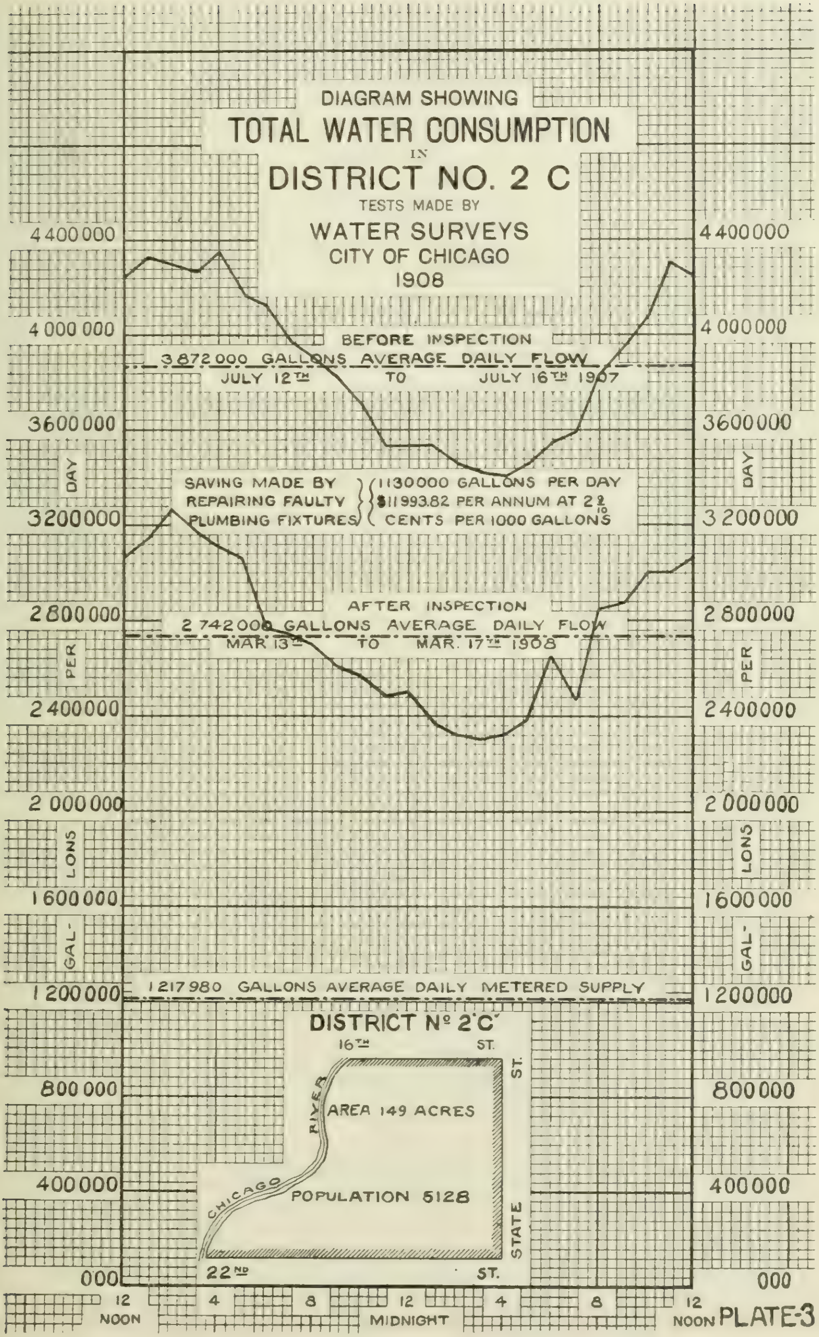


DIAGRAM SHOWING
TOTAL WATER CONSUMPTION
IN
DISTRICT NO. 2 C
TESTS MADE BY
WATER SURVEYS
CITY OF CHICAGO
1908
BEFORE INSPECTION
3 872 000 GALLONS AVERAGE DAILY FLOW
JULY 12TH TO JULY 16TH 1907
SAVING MADE BY REPAIRING FAULTY PLUMBING FIXTURES
1130000 GALLONS PER DAY
$11993.82 PER ANNUM AT 2 1/10 CENTS PER 1000 GALLONS
AFTER INSPECTION
2 742 000 GALLONS AVERAGE DAILY FLOW
MAR 13TH TO MAR. 17TH 1908
1 217 980 GALLONS AVERAGE DAILY METERED SUPPLY
DISTRICT Nº 2 'C'
16TH ST.
ST.
RIVER
AREA 149 ACRES
CHICAGO
POPULATION 5128
STATE
22ND ST.
4 400 000
4 000 000
3 600 000
3 200 000
2 800 000
2 400 000
2 000 000
1 600 000
1 200 000
800 000
400 000
000
GAL-LONS PER DAY
12 NOON
4
8
12 MIDNIGHT
4
8
12 NOON

PLATE-3

class residences. The area covers 149 acres and the population numbers 5128.

The supply for this district was 3,872,000 in July, 1907, with a night rate of 92½ per cent of the average daily rate of supply.

A house to house inspection was made in subdivisions No. 1, No. 5 and No. 10, covering about one-third of the area. A total saving of 1,113,000 gallons per day, or 29 per cent of the supply, was made in this district. About 150,000 gallons, or 13½ per cent of this saving, was made by abandoning old mains.

The reduction of supply in this district did not change the relation of the night rate to the average daily rate of supply, showing that the reduction was due to a decrease of constant waste or leakage.

The remainder of this district is in progress of house to house inspection. This will result when completed in 20 per cent more saving, making a total reduction of 50 per cent in the consumption.

District No. 6.

This section is a low-class dwelling and tenement house district, having a population of 23,000 and an area of 319 acres. It lies between Harrison and Fourteenth Streets and extends from Halsted Street to the south branch of the Chicago River.

The supply for this district was 7,200,000 gallons per day. The Municipal Light Plant used a rate of 1,400,000 gallons of water from 6 p.m. to 6 a.m. Deducting this amount of water gave a minimum night rate of 90 per cent of the average daily supply.

A total of 1903 leaky fixtures were found by house to house inspection, 753 of which were closets. In addition 1526 underground leaks were discovered.

After making a complete house to house inspection over the entire district and repairing faulty plumbing fixtures, the consumption was reduced to 4,700,000 gallons per day. This was a saving of over 35 per cent or 2,600,000 gallons per day. At 2.9 cents per 1000 gallons, this saving amounts to $27,521 per annum.

After making plumbing repairs the minimum night rate was only 48 per cent of the average daily rate of consumption

A further saving of more than a million gallons per day can be made by cutting out the supply mains under railway tracks in the eastern portion of the district.

The revenue for unmetered supply in this section was increased by repairing leaky fixtures, from 1.96 cents to 4.38 cents per 1000 gallons, or an increase of 123 per cent in revenue for the unmetered supply.

District No. 7

This section lies directly south of district No. 6. It is a low-class residence and tenement-house section excepting along the river front, which is a lumber district. The population numbers 17,200 and the area covers 304 acres.

The total supply was 3,800,000 gallons per day. The minimum night rate was 3,150,000 gallons per day, or 83 per cent of the total supply. The metered consumption was 1,052,000 gallons per day.

A house to house inspection was made and a saving of 880-000 gallons per day was obtained. This saving amounted to $9314 per annum, at 2.9 cents per 1000 gallons.

District No. 11

The southern portion of this district is occupied by manufacturing plants, while the northern part is made up of low-class tenement houses. It covers an area of 250 acres and has a population of 2400.

The total supply for seven days in October, 1908, was 3,490,-000 gallons per day. There was little decrease in the consumption at night. The metered consumption was 499,410 gallons per day.

A subdivision test was run at night to localize the flow, which disclosed an open 4-inch blow-off under 20 pounds pressure running into a sewer, and wasting water at the rate of 1,443,000 gallons per day.

The work of saving the supply in this district is incomplete, as a house to house inspection was not made. This work will be done during the season of 1909.

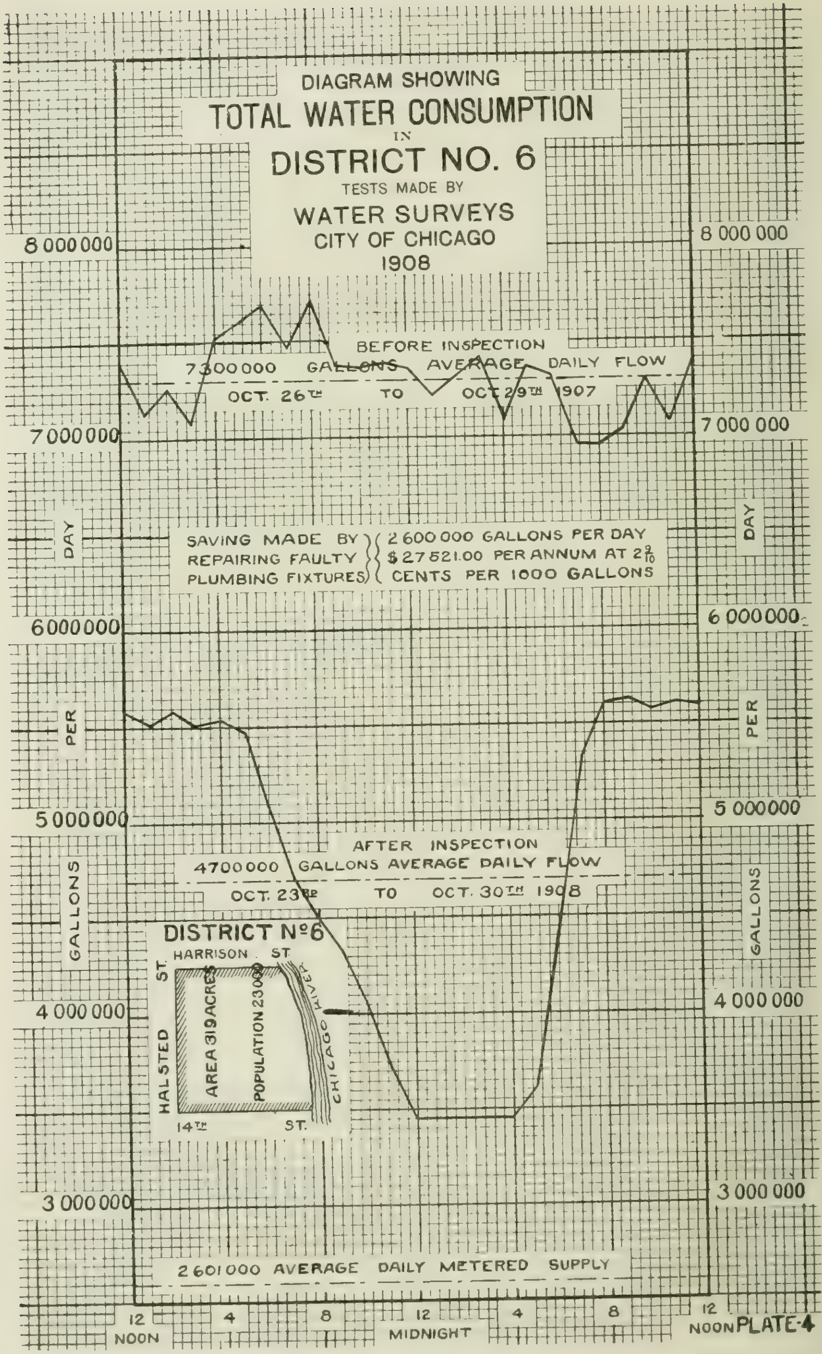


DIAGRAM SHOWING
TOTAL WATER CONSUMPTION
IN
DISTRICT NO. 6
TESTS MADE BY
WATER SURVEYS
CITY OF CHICAGO
1908
8 000 000
7 000 000
6 000 000
5 000 000
4 000 000
3 000 000
GALLONS PER DAY
BEFORE INSPECTION
7300000 GALLONS AVERAGE DAILY FLOW
OCT. 26TH TO OCT. 29TH 1907
SAVING MADE BY REPAIRING FAULTY PLUMBING FIXTURES
2 600 000 GALLONS PER DAY
$ 27 521.00 PER ANNUM AT 2 9/10 CENTS PER 1000 GALLONS
AFTER INSPECTION
4700000 GALLONS AVERAGE DAILY FLOW
OCT. 23RD TO OCT. 30TH 1908
DISTRICT No 6
HARRISON ST.
HALSTED ST.
14TH ST.
CHICAGO RIVER
AREA 319 ACRES
POPULATION 23000
2 601 000 AVERAGE DAILY METERED SUPPLY
12 NOON
4
8
12 MIDNIGHT
4
8
12 NOON

PLATE-4

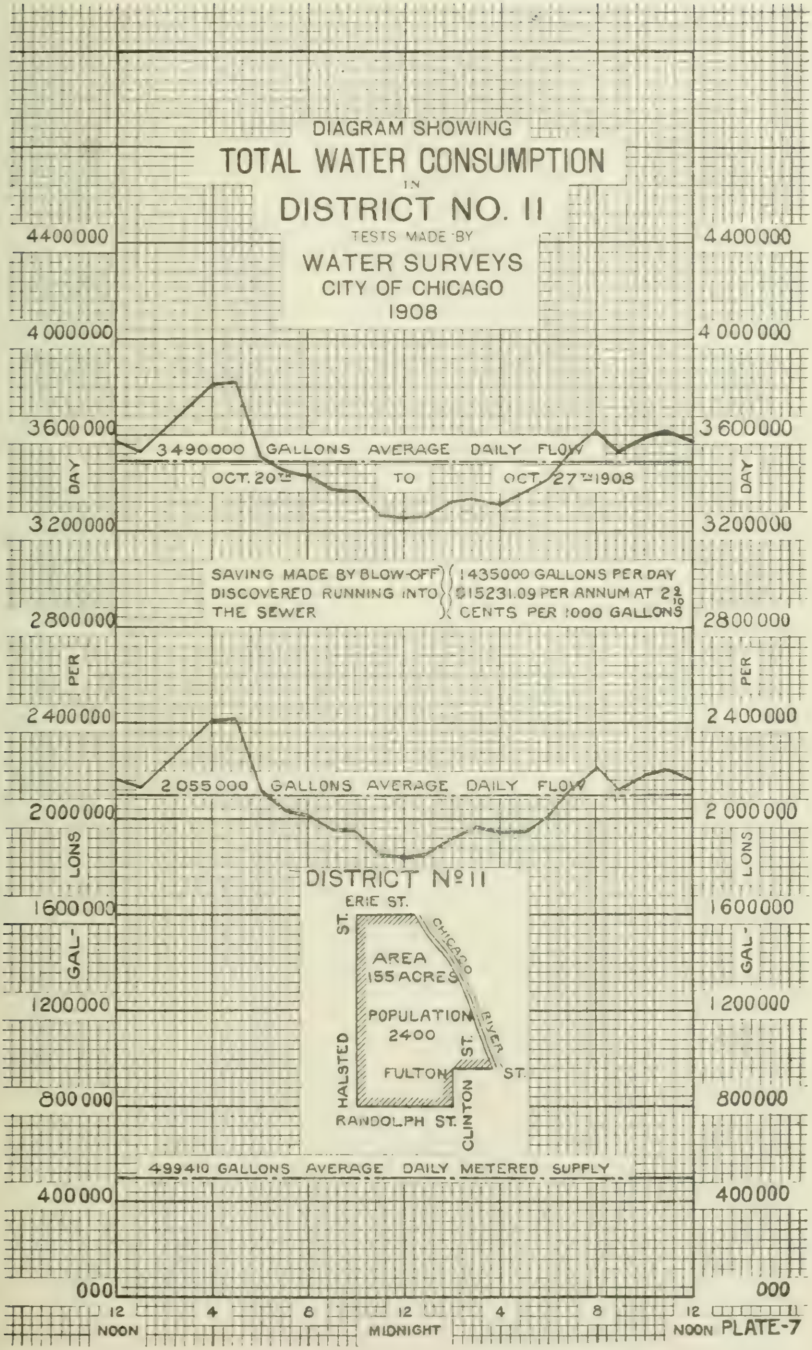


DIAGRAM SHOWING
TOTAL WATER CONSUMPTION
IN
DISTRICT NO. 11
TESTS MADE BY
WATER SURVEYS
CITY OF CHICAGO
1908
4400000
4000000
3600000
3200000
2800000
2400000
2000000
1600000
1200000
800000
400000
000
GAL-
LONS
PER
DAY
3490000 GALLONS AVERAGE DAILY FLOW
OCT. 20TH TO OCT. 27TH 1908
SAVING MADE BY BLOW-OFF DISCOVERED RUNNING INTO THE SEWER
1435000 GALLONS PER DAY
$15231.09 PER ANNUM AT 2 2/10 CENTS PER 1000 GALLONS
2055000 GALLONS AVERAGE DAILY FLOW
DISTRICT Nº 11
ERIE ST.
CHICAGO RIVER
AREA 155 ACRES
POPULATION 2400
HALSTED ST.
FULTON ST.
CLINTON ST.
RANDOLPH ST.
499410 GALLONS AVERAGE DAILY METERED SUPPLY
12 NOON
4
8
12 MIDNIGHT
4
8
12 NOON

PLATE-7

Table showing Revenue of Metered and Unmetered Water Supply per 1000 Gallons for the Seven Districts Surveyed by Water Surveys during 1907

COLUMN NO.		1	2	3	4	5	6	7	8
				SUPPLY		ANNUAL REVENUE		REVENUE PER 1000 GALLONS	
DISTRICTS		AREA IN ACRES	POPULATION 1907	Gals. Av. Daily Unmetered During Test 1907	Gals. Av. Daily Metered Including Period of Test 1907	Frontage Revenue for 1907	Metered Revenue for 1907	For Unmetered Supply 1907	For Metered Supply 1907
Dist. No.	1	720	700,000 floating	3,842,000	11,658,000	$8,985.00	$290,187.00	$0.0064	$0.0682
" "	2	666	26,126	9,660,000	3,840,000	42,368.00	93,483.00	0.0120	0.0667
" "	3	229	9,229	3,610,000	1,640,000	16,292.00	41,003.00	0.0123	0.0685
" "	4	320	22,704	2,718,000	1,672,000	26,682.00	34,605.00	0.0269	0.0567
" "	5	258	20,000	2,639,000	611,000	29,443.00	13,423.00	0.0305	0.0602
" "	6	419	28,476	4,699,000	2,601,000	33,572.00	66,009.00	0.0196	0.0695
" "	7	304	13,651	2,748,000	1,052,000	20,775.00	27,382.00	0.0207	0.0713

Column 3 was obtained by deducting column 4 from total supply into district.
District supply was measured for seven days by pitometer.
Column 4 was obtained from meter reading records for the months of the test.

Districts No. 12, No. 13, No. 14, No. 15, No. 17, and No. 18

These six districts cover an area of one square mile. They are located in one of the most thickly populated portions of the City. This territory is a low-class tenement-house section and has a total population of 53,800.

The total supply for this square mile during 1908 was 10,947,000 gallons per day, or about 202 gallons per capita. The total metered supply was 898,000 or 17 gallons per capita. The minimum night rates in all six districts were high, ranging from 80 per cent to 90 per cent of the average daily supply.

A complete house to house inspection was made over the whole territory, and the condition of the plumbing was found generally bad.

A total of 2589 closets was found leaking, and 1897 underground leaks inside premises were discovered.

The total supply after the district was inspected, and the plumbing repairs were made, was 5,734,000 gallons per day. This was a saving of about one-half the supply, or a reduction from 202 to 106 gallons per capita. At 2.9 cents per 1000 gallons this amounted to a saving in revenue of $55,465 per annum.

In addition to making this saving the water pressure over the territory was increased about 5 to 10 pounds, and all valves in poor condition were placed in good repair.

The minimum night rate remaining in this square mile after repairing plumbing fixtures was 4,200,000 gallons per day. Assuming 25 per cent of this as legitimate night consumption, there is remaining in this section a waste of 3,150,000 gallons per day, or 59 gallons per capita, which is due to underground leakage in the mains and old services.

Districts No. 21, No. 22 and No. 23.

This territory covers 749 acres or 1.17 square miles. It is a low-class dwelling district, and has a population of 37,232.

The total daily supply before an inspection was made was 6,078,500 gallons per day. The total metered consumption was 702,000 gallons per day. The combined minimum night rate after the inspection was 3,800,000 gallons per day, which is 84 per cent of the average daily supply.

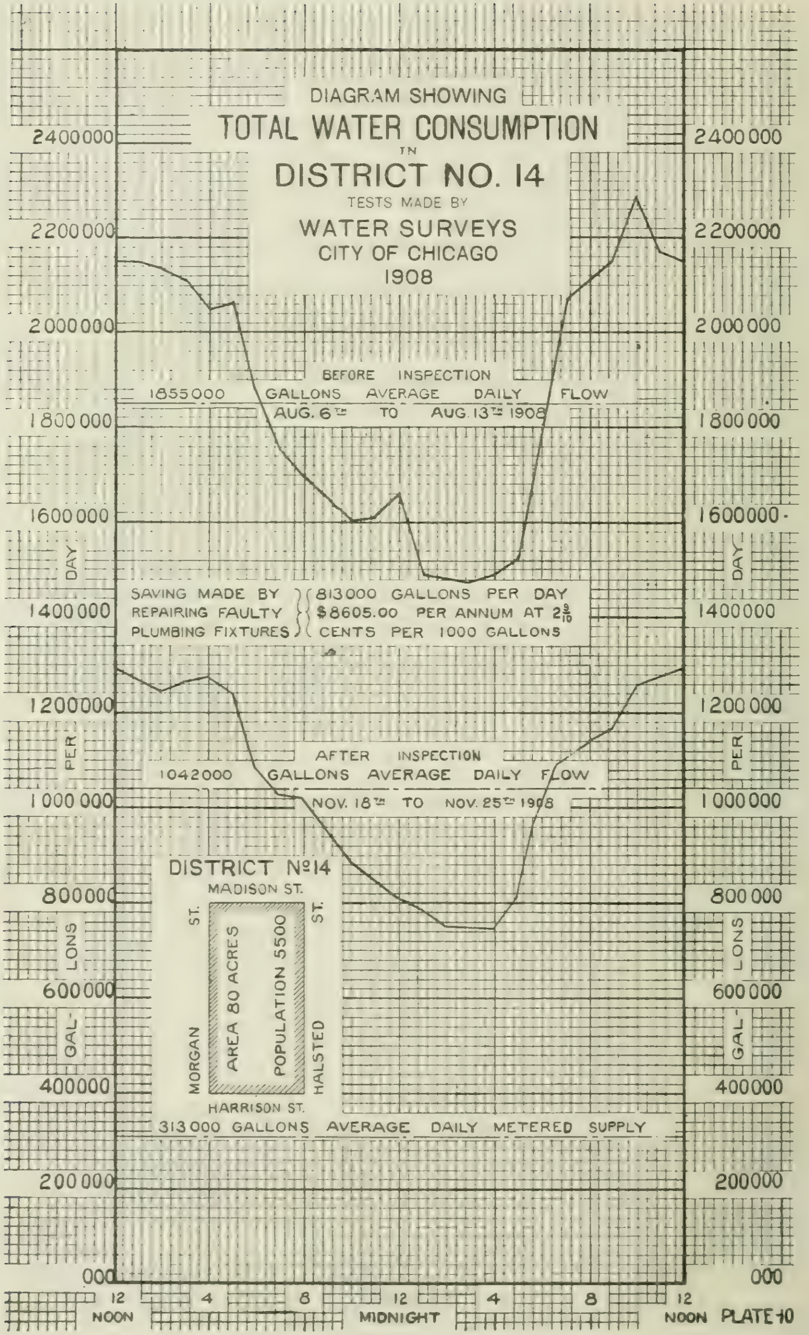


DIAGRAM SHOWING
TOTAL WATER CONSUMPTION
IN
DISTRICT NO. 14
TESTS MADE BY
WATER SURVEYS
CITY OF CHICAGO
1908
BEFORE INSPECTION
1855000 GALLONS AVERAGE DAILY FLOW
AUG. 6TH TO AUG. 13TH 1908
SAVING MADE BY REPAIRING FAULTY PLUMBING FIXTURES
813000 GALLONS PER DAY
$8605.00 PER ANNUM AT 2 3/10 CENTS PER 1000 GALLONS
AFTER INSPECTION
1042000 GALLONS AVERAGE DAILY FLOW
NOV. 18TH TO NOV. 25TH 1908
DISTRICT Nº14
MADISON ST.
HARRISON ST.
MORGAN ST.
HALSTED ST.
AREA 80 ACRES
POPULATION 5500
313000 GALLONS AVERAGE DAILY METERED SUPPLY
2400000
2200000
2000000
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
000
GAL-LONS PER DAY
12 NOON
4
8
12 MIDNIGHT
4
8
12 NOON

PLATE 10

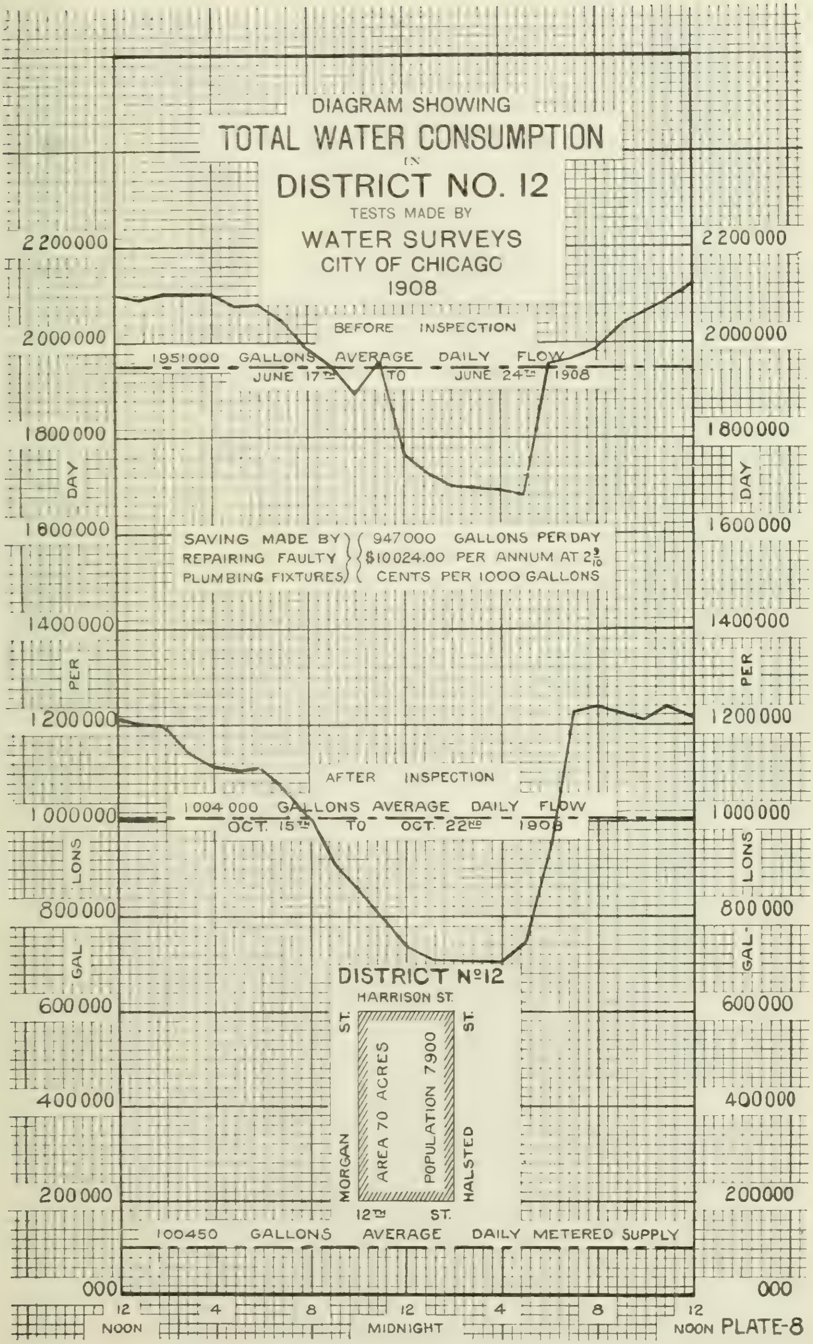


DIAGRAM SHOWING
TOTAL WATER CONSUMPTION
IN
DISTRICT NO. 12
TESTS MADE BY
WATER SURVEYS
CITY OF CHICAGO
1908
BEFORE INSPECTION
1951000 GALLONS AVERAGE DAILY FLOW
JUNE 17TH TO JUNE 24TH 1908
SAVING MADE BY REPAIRING FAULTY PLUMBING FIXTURES
947000 GALLONS PER DAY
$10024.00 PER ANNUM AT 2 9/10 CENTS PER 1000 GALLONS
AFTER INSPECTION
1004 000 GALLONS AVERAGE DAILY FLOW
OCT. 15TH TO OCT. 22ND 1908
DISTRICT Nº12
HARRISON ST.
MORGAN ST.
HALSTED ST.
12TH ST.
AREA 70 ACRES
POPULATION 7900
100450 GALLONS AVERAGE DAILY METERED SUPPLY
2 200 000
2 000 000
1 800 000
1 600 000
1 400 000
1 200 000
1 000 000
800 000
600 000
400 000
200 000
000
GAL-LONS PER DAY
12 NOON
4
8
12 MIDNIGHT
4
8
12 NOON

PLATE-8

The general condition of the plumbing in this territory was found in poor repair. A total of 13,806 places were inspected, 961 closets were found leaking, and 1859 underground leaks inside premises were discovered. A large number of the leaky closets were long hopper closets directly connected to the water main and operated with a rod. These closets should be prohibited unless provided with a meter.

The saving made by repairing the plumbing fixtures was 2,195,000 gallons per day, amounting to $23,244 per annum at 2.9 cents per 1000 gallons. This was a reduction in the consumption from 180 to 120 gallons per capita, or a saving of 60 gallons per capita.

Assuming 25 per cent of the minimum night rate as legitimate consumption, there is an underground leakage of approximately 2,850,000 gallons per day, or 77 gallons per capita remaining in this territory.

GENERAL

From 1890 to 1907 the daily consumption of water in the city of Chicago increased from 126 to 204 gallons per capita. The total daily pumpage for this period increased from 152,372,000 gallons per day to 454,615,000 gallons per day.

The Water Survey Division which has been conducting a systematic investigation for the past two years has surveyed approximately ten square miles in the older and central portion of the city. The work consisted in laying out the city into districts ranging from 75 to 300 acres, analyzing the water consumption and eliminating the waste as far as possible.

A total of 35 districts were surveyed in this manner which show that the rate of supply during the night time is little less than for the day period. This is indicative of a large waste and leakage. The actual net usage in the districts where house to house inspections and plumbing repairs were made, show that from 45 to 60 gallons per capita meets the demand for domestic consumption, and in some sections this is as low as 30 gallons per capita.

The city of Chicago has eight large pumping stations and three small auxiliary plants for raising the pressure in outlying

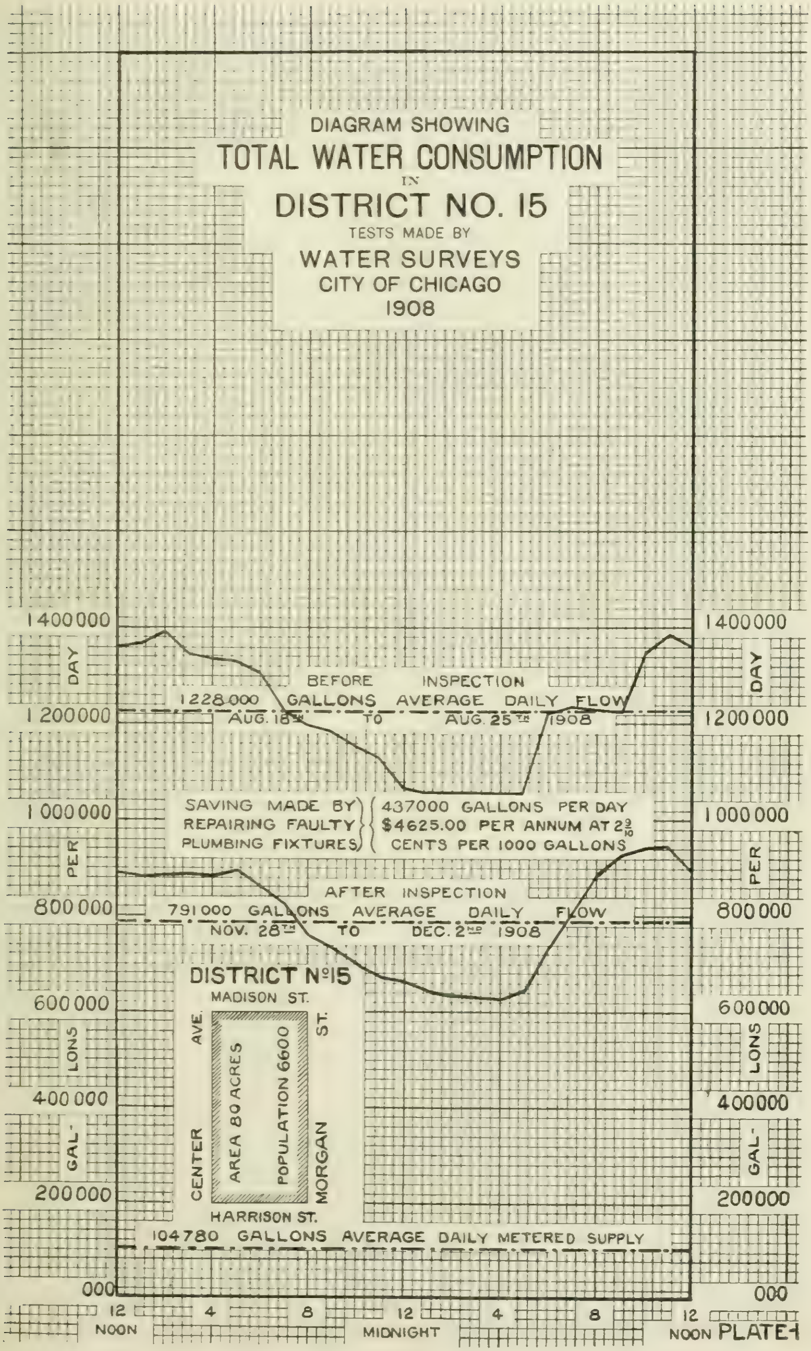


DIAGRAM SHOWING
TOTAL WATER CONSUMPTION
IN
DISTRICT NO. 15
TESTS MADE BY
WATER SURVEYS
CITY OF CHICAGO
1908

PLATE 1

Table showing Increase in Revenue for Unmetered Supply after Repairing Plumbing Fixtures for Districts Inspected by "Water Surveys," City of Chicago, 1908

DISTRICT	AREA IN ACRES	POPULATION 1908	SUPPLY IN GALLONS PER DAY			REVENUE PER ANNUM		REVENUE PER 1000 GALLONS				
									FOR UNMETERED SUPPLY			
											INCREASE	
			Total Metered Before Inspection	Total Unmetered Before Inspection	Total Saving After Inspection	Total Metered	Total Frontage	For Metered Supply	Before Inspection	After Inspection	Amount	Percentage
2B	94	600	275,920	1,344,080	328,000	$7,069.10	$991.00	$0.07	$0.002	$0.0025	$0.0005	25
2C	149	5,128	1,217,980	2,654,020	1,130,000	31,204.67	8200.50	0.07	0.0084	0.0150	0.0066	79
6	319	23,000	‡2,601,000	‡4,699,000	2,600,000	‡66,009.00	‡33,572.00	‡0.0695	‡0.0196	0.0438	0.0242	123
7	304	17,200	‡1,052,000	‡2,748,000	880,000	‡27,382.00	‡20,775.00	‡0.0713	‡0.0207	0.0304	0.0097	47
8	170	4,150	721,000	2,148,000	———	18,473.00	6,754.00	0.07	0.0086	———	———	———
11	155	2,400	499,400	2,990,590	1,434,724	12,794.87	5,373.00	0.07	0.0058	0.0100	0.0042	72
12	70	7,900	100,450	1,850,550	947,000	2,573.69	13,384.25	0.07	0.0190	0.0406	0.0216	114
13	90	10,200	53,830	2,012,670	1,029,500	1,379.34	17,517.25	0.07	0.0237	0.0461	0.0124	52
14	80	5,500	313,540	1,541,460	813,000	8,032.82	10,960.50	0.07	0.0190	0.0410	0.0220	116
15	89	6,600	104,780	1,123,220	†437,000	2,684.48	11,697.50	0.07	0.0220	†0.0360	†0.0140	†64
21	164	7,221	236,800	1,420,200	†340,000	6,066.83	10,053.25	0.07	0.0193	†0.0245	†0.0052	†27
	1,675	89,899	7,176,700	24,531,790	9,939,220	183,669.80	139,278.25					

†Incomplete on account of cold weather.

‡Figures for 1907.

districts. During 1908 the total average pumpage for the eight large stations was 467,000,000 gallons per day. Of this supply 85 per cent is unmetered and the remainder is metered supply.

The total number of services in the city of Chicago for 1908 was approximately 373,000, less than 4 per cent of which are metered. It can be seen from this that 70,000,000 gallons per day, or 15 per cent of the supply, is taken through 14,724 meters.

The investigations by the Water Survey Division show that there is a high plumbing leakage in the city of Chicago due to the neglect of owners and tenants in making repairs, which wastes from 35 to 45 per cent of the total supply. In one square mile on the west side, where all plumbing was inspected and repaired, a total saving of 5,700,000 gallons per day, or 48 per cent of the supply, was made.

There is also an excessive underground loss of water due to leaks in the street mains and old service pipes, principally the latter, which wastes from 25 to 35 per cent of the total supply. In three districts on the south side, covering an area of 1.17 square miles, the underground leakage was found to be approximately 2,850,000 gallons per day or 47½ per cent of the total supply.

In addition to the plumbing and the underground leakage there are other sources of loss of water, which in comparison are small and probably do not exceed 5 to 10 per cent of the total supply.

From the above sources of waste and leakage it can be seen that the total loss of water in the districts surveyed in the City of Chicago amounts to from 70 to 80 per cent of the total supply.

The meter rate for water for the city of Chicago is seven cents per 1000 gallons. The city receives less than two cents per 1000 gallons for its unmetered water which includes the frontage supply, waste and leakage. This rate is less than the cost of production.

The installation of a large number of meters would help materially to restrict the useless and wilful waste of water common throughout the city. The increase in revenue from this expenditure would insure a large return on the investment.

An increase in the number of meters is not a cure all for the high rate of water consumption in the city of Chicago. The underground leakage is more serious than at first supposed, and

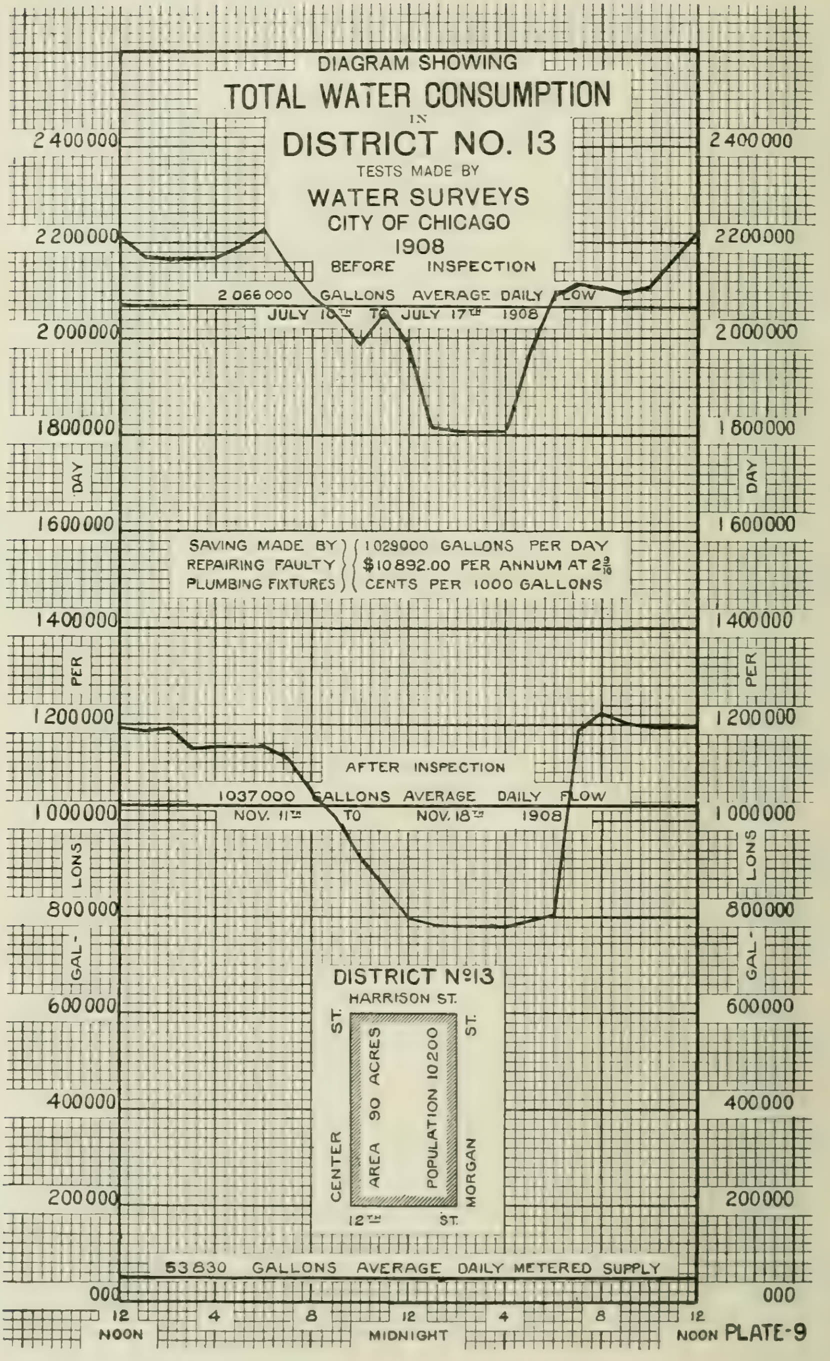


DIAGRAM SHOWING
TOTAL WATER CONSUMPTION
IN
DISTRICT NO. 13
TESTS MADE BY
WATER SURVEYS
CITY OF CHICAGO
1908
BEFORE INSPECTION
2 066 000 GALLONS AVERAGE DAILY FLOW
JULY 16TH TO JULY 17TH 1908
SAVING MADE BY REPAIRING FAULTY PLUMBING FIXTURES
1 029000 GALLONS PER DAY
$10 892.00 PER ANNUM AT 2 9/10 CENTS PER 1000 GALLONS
AFTER INSPECTION
1037000 GALLONS AVERAGE DAILY FLOW
NOV. 11TH TO NOV. 18TH 1908
DISTRICT No13
HARRISON ST.
CENTER ST.
MORGAN ST.
12TH ST.
AREA 90 ACRES
POPULATION 10200
53 830 GALLONS AVERAGE DAILY METERED SUPPLY
2 400000
2 200000
2 000000
1 800000
1 600000
1 400000
1 200000
1 000000
800000
600000
400000
200000
000
GAL- LONS PER DAY
12 NOON
4
8
12 MIDNIGHT
4
8
12 NOON

PLATE-9

the reason for this is not difficult to understand. As extensions to the street mains were made, service pipes were laid at intervals of 25 feet or more to both curbs. This was done to obviate the necessity of tearing up the pavement whenever a consumer wished to take water. A considerable number of these services in each block were never used because structures were not erected on each lot. Later many services that were in use were abandoned for larger services, when building changes and developments in the growth of the city were made. After a time the old abandoned services deteriorated and leaked away underground. This source of waste cannot be controlled by the installation of meters.

The loss of water due to pipe-joint leakage is comparatively small, but occasionally large leaks from this source are discovered. The distribution system of the city of Chicago lies in a sandy subsoil which affords an easy channel for the water to escape without showing on the surface.

About one-half of the present distribution system was installed before 1890, at which time the city operated approximately 1200 miles of mains. In 1881 the city of Chicago operated about 475 miles of mains. In the older portion of the city, where the surveys are in progress, it is fair to assume that the services installed prior to 1881 are leaking badly. The reason for this is that whenever services were cut off on account of building construction they were not abandoned properly. I am reliably informed by men long in the service of the city, that whenever a service was replaced by a larger service, that a not uncommon custom was to close the ends of the pipe in a more or less temporary manner, or even to batter up the ends and leave them. Where electrolitic action occurs, and this is a common cause of leakage, the lead service pipe disintegrates more or less rapidly and creates an underground leakage which is not easily discovered.

It can be seen from the above that the problem of coping with the underground leakage in Chicago is a most important one. The cost of tearing up paved streets, stripping the mains and eliminating all leaky service pipes is prohibitory. This work can be done, however, where the leakage is known to be high and excessive, at a reasonable cost at the time the streets are repaved.

DISCUSSION

President French: This is a very interesting paper and I hope it will bring out a lively discussion. I would like to ask the speaker how the consumption is figured, whether by plunger displacement or by Venturi meter measurement? He referred to the total consumption.

Mr. T. C. Phillips: The total consumption is taken from the pumpage reports. I want to say that we have made a great many tests for slippage. We used a pitometer to make these slippage tests. Recently we had occasion to make a test at a large pumping station; one of the engines was slipping something like 12 per cent. After the pump had been repacked and repaired the slippage was reduced to about 4 or 5 per cent, which we consider pretty good. I have had occasion to make slippage tests at other stations where the slippage was about 10 per cent. Occasionally we find an engine that is bad where the slippage runs up as high as 20 per cent. At one station where we have an old Quintard beam engine I made some tests that ran from 23 to 28 per cent. These engines were installed in 1876 and 1884. I made tests in this station for about a month, trying to get good conditions to test under. I could not tell whether the slippage was due to the old style valves which they had, or whether it was the packing, or due to air. I found that difference or slippage between the pump recorder and our instruments.

President French: How did you arrive at the cost of 2.9 cents per 1000 gallons; how was that made up? What does the cost consist of?

Mr. T. C. Phillips: That 2.9 cents per 1000 gallons was made up by taking the total amount of expenditures for all purposes and the total pumpage for the year was 166,000,000,000 gallons; the total expenditure was $4,819,000. You will find this carefully compiled in the 1907 report of the city of Chicago.

President French: That covers all operating expenses and labor?

Mr. T. C. Phillips: Yes sir, all expenses of operation. The expenditures for operation figure up $1,484,485.60.

President French: If I remember right, you are able to account for the matter of 25 or 30 per cent of your total water pumpage?

Mr. T. C. Phillips: I should say so in the district which I surveyed. I have not covered the entire city. I have not covered the districts which represent the better class of residence sections; in that territory I am unable to say; but in the territory which I have surveyed, which covers about ten square miles located in the central portion of the city, I should say that we could only account for about 30 per cent. It varies a little in some districts, better in some, and not so good in others.

Mr. S. J. Rosamond: There is one point which perhaps the speaker covered, but I did not catch. He spoke of what he calls the Loop District as being a wholly metered district, or an almost wholly metered district. I should like to know how the consumption of that district compares with the other districts surveyed?

Mr. T. C. Phillips: I cannot answer as to the consumption per capita in the Loop District, on account of the large floating population. I consulted all the sources of information from which I thought I might obtain correct figures pertaining to the population, but I am only able to make a more or less intelligent guess as to this. Our figures are not complete enough at this time to answer your question.

Mr. S. J. Rosamond: Can you give us some idea of the consumption per tap?

Mr. T. C. Phillips: We do not have a figure showing the complete number of services in the Loop section, so I cannot give you that. A report was recently gotten up in conjunction with the proposed sub-way report which gives very carefully a great deal of valuable data about the present consumption and the future needs and all that sort of thing. You can obtain that information if you ask for it, if you are further interested.

President French: How about the pressure you are pumping against, is it exceedingly high, or is it fairly so?

Mr. T. C. Phillips: It ranges from 45 pounds at the pumping station to as low as 15 pounds in some of the districts. In the districts that we have been surveying the pressure runs approximately around 20 to 25 pounds and sometimes as high as 30 pounds.

President French: I cannot understand this very low cost of 2.9 cents per 1000 gallons, and it seems as if some other expense has been omitted. The pressure is low, which is one reason why the cost should be low. Possibly your fuel is exceedingly cheap. Are you burning coal or oil?

Mr. T. C. Phillips: Coal, entirely.

President French: It costs you about what?

Mr. T. C. Phillips: I do not know; do you know, Mr. Levering?

Mr. W. A. Levering: About $2 a ton.

President French: It is a remarkably low figure. I could not understand how it was possible to do it.

Mr. H. M. Winslow: It seems to me that if the city of Chicago could eliminate all other waste and get their pumping down to about one-third of what they are pumping now, the cost then would be about between eight and nine cents per 1000 gallons. Suppose that you reduce your pumpage by two-thirds, would you save more than $500,000 out of that $4,800,000? You would not save any depreciation; you would only save on a fraction of the operating expenses; so I think it would cost about nine cents a thousand gallons to pump one-third as many gallons as you are pumping now.

Mr. T. C. Phillips: In answer to the question as to cost, I want to say that it is very difficult to show to our people at Chicago just what we are doing. If we talk to them in gallons they do not understand as well as when we talk in dollars and cents. We are better understood when we use those terms. I obtained these figures from the 1907 annual report, from which I calculated the saving in supply meant so much in money.

Mr. H. M. Winslow: I just want to know if you made any calculations as to how much that was? I think you are saving about three cents, because if you cut down your consumption to over 55,000,000,000 you would raise your total cost to nine cents, and one-third of that would be pumpage cost; so I think you would be saving three cents.

Mr. T. C. Phillips: At the present time the city cannot manufacture and deliver water for three cents per 1000 gallons.

In certain districts the city of Chicago is not getting the cost of production. We pump water as far as eleven miles, and in some instances pump it twice. And for this reason I do not think we can pump and deliver water at present for three cents a thousand gallons.

Mr. D. R. Gwinn: I want to ask you whether in making up that figure of 2.9 cents you included the cost of the total investment of your plant?

Mr. T. C. Phillips: Yes; it includes the cost of the total investment of our plant. This is a statement of estimated cost of supplying water to consumers in Chicago for the year 1907. I copied these figures almost verbatim, and I want to show where I got them. The amount of interest on invested capital was assumed at 3 per cent and amounted to $1,236,626.68. Let me explain again about this. You do not seem to understand. If you are interested in these figures you can find them all in the 1907 report of the city of Chicago. I copied the figures and inserted them in my paper so that you could see where I obtained this 2.9 cents per 1000 gallons. I have taken 2.9 cents per 1000 gallons, because I can show the city where they can make money by repairing their plumbing leakage and other leakage. I had to take some figure to show what it meant in money; therefore I have taken 2.9 cents per 1000 gallons, which is low.

Mr. D. R. Gwinn: I take it that the interest charges there do not include interest on the drainage canal, which is really a part of the water works system of Chicago, for unless the drainage canal had been built it would have been necessary for the city of Chicago to put in purification works; hence the cost of the drainage canal should be charged up to the water department. Furthermore, if Mr. Phillips had deducted the slippage of those pumps, I take it that the figure of 2.9 cents per 1000 gallons would have been changed very materially. If you take the slippage from the total pumpage as shown by the pump counters, you would probably find that your rate per 1000 gallons would be considerably higher.

Mr. T. C. Phillips: I believe our slippage is not much greater than 10 per cent. I have had occasion to go over a great many engines, and the slippage is not very high except in this one old station, where it might be anything. Those engines are soon to be replaced.

Mr. S. J. Rosamond: I am glad that the speaker has been so frank. Figures of this kind that get into the hands of aldermen work an injustice to a privately owned water works. The alderman takes figures of this kind, goes into the council meeting and says, "Here is Chicago delivering water at a cost to the city of 2.9 cents per 1000 gallons, let us get after the water company!" Then there is a row on hand with the private company.

Mr. T. C. Phillips: I want to call your attention to the fact that we have not been spending our time to any great extent in determining what the whole situation is in the city of Chicago. We have been extending the surveys outward from the Loop District towards the residential part of the city as this work was very profitable. The water was measured district by district. There is no slippage to be considered when measuring the water flowing into a district, as the water supply for a district is measured by installing one, two or three pitometers for a week or ten days. The amount of slippage at a pumping station has nothing to do with the amount of water feeding a district. I am trying to cut down the large waste of water in the city of Chicago. The curve of consumption compiled from the pumpage records shows that for the last two years there has been a steady increase in the per capita consumption of water. During the past year practically no increase in this curve was felt, and if we are permitted to spend $55,000 a year, which sum was appropriated for 1909, I think we can begin to bend that curve downward a little. However, $55,000 is not very much money to cope with a problem like the one we have in the city of Chicago.

Mr. J. M. Diven: How do you test valves, to be sure they are not leaking?

Mr. T. C. Phillips: Whenever a valve is closed down, it does not mean that valve is the only one we operate. We go to the next valve beyond, and close it, and open up a hydrant between them. If the hydrant does not go dry immediately several valves are closed down, until we have a tight section in order to find out if the particular valve in question is closed tight. When all those valves are down tight a hydrant opened up inside of the territory will go dry. If we find that we cannot get a valve shut down, we notify the foreman of the district and have him come out with a gang and repair it. In this manner we are sure of tight valves and there is no question about our having tight districts.

President French: Where have you found most of your leakage on your engines? Has it been through your packed plungers, or through your valves?

Mr. T. C. Phillips: I have had more experience with 68th Street than some of the other stations. Whenever Mr. Reynolds, the Chief Engineer, repacks his plungers we cut the slippage down from about 9 or 10 per cent to about 4 per cent.

President French: It has been my own experience frequently that considerable valve leakage is apt to throw one's slippage losses very high, perhaps as high as 30, 40, or 50 per cent. If you only had 20 per cent or less leakage, I wondered whether you had located it in the valves or in your packing. That was the only point that I had in my mind. Is there any further discussion of this paper?

Mr. George Houston: I would like to ask Mr. Phillips with reference to the consumption, comparatively, between day and night. What hours do you include in that as covering the night consumption, that is, from what hour to what hour?

Mr. T. C. Phillips: This varies a little in the different districts, generally from 12 o'clock midnight to 4 o'clock in the morning, represents the minimum night rate.

Mr. D. H. Maury: As to slipping in pumps, it has been my own personal experience that this is usually less than has been claimed of late years; and while I have upon one occasion found a small pump that slipped 80 per cent, it was an old pump that had holes clear through its plungers and working against high pressure. In Chattanooga I had a case where I tested three pumps with a Venturi meter, pumps which had been in service about nineteen years and had been given no special care other than that required daily at a station to keep them in order. The plunger and ring were without any packing at all, simply a cast iron plunger; and the slippage ran less than 7 per cent right straight along month after month; which I think goes to refute some of the statements as to very large slippage being commonly found in pumping stations, especially with engines of that class. I think the figures are correct; in fact, I have every reason to believe they are. The slippage was measured by a Venturi meter which was presumably standardized before it was sent to us, and the operation of the meter has been thoroughly checked.

President French: I take it that Mr. Maury is speaking of a direct acting horizontal pump.

Mr. D. H. Maury: This is a vertical pump, not a packed plunger, just a cast iron plunger and ring.

President French: I agree with you fully on that question of slippage on plungers of that type as not being anything like what has been frequently reported. I think that nine times out of ten, or even a much greater percentage than that, it is a question of losses through the valves, not the plungers.

Mr. D. H. Maury: Yes, sir; I think most of that loss was through the valves.

Mr. Phil Carlin: Do you find any trouble with electrolysis?

Mr. T. C. Phillips: I have not touched upon the question of electrolysis very much; but we find quite a little of this in Chicago. We have made an effort several times to have a Division organized and some money appropriated to pursue this work carefully, but so far have not been successful. In a large city like Chicago they move slowly. We hope some day to get some one to come and make this survey for us, or that we may get a department of the city government to cope with this problem. There is a great deal of it. We hear continually from the foremen of the water pipe extension districts and other sources where complaints are received of this sort, of trouble; and occasionally when we strip a main to locate leakage we have found considerable electrolysis. I have not said much about this, because so far I have not had enough opportunity to follow out the causes of the large underground leakage. I have reserved this for a time when I shall know more about the underground leakage than I do now. But I can say that we have had considerable trouble from electrolysis.

Mr. A. A. Reimer: Undoubtedly there is a great deal of need for the kind of work that Mr. Phillips has been doing in Chicago; but I think, as representing the smaller cities, we may not realize the advantage that would come to us from this same class of work if carried out in our cities. We may think that in our case it may not be so important because we may be dealing with tens of thousands of gallons where Mr. Phillips deals with hundreds of thousands. In my home city of East Orange, N. J., where the total pumpage is about 3,000,000 gallons a day, about two years ago I began making tests by placing a by-passed meter at the valves, and discovered that there was a high night rate. I got a small appropriation for carrying on some work along this line, and the work demonstrated that there was an almost negligible leakage in the mains and valves; but it also showed that there was a very heavy leakage in the services and fixtures of the houses beyond the curb cocks. Last year I estimated after studying the situation pretty carefully, that we were wasting over 50 per cent of our pumpage. As our supply is artesian, it meant that our supply was rapidly fading away on account of the enormous demand being made on it. I recommended a pitometer survey along the same lines that Mr. Phillips is carrying out in Chicago. Fortunately permission was granted, and we went ahead with it, and the estimate that I made last year was shown to be low. We surveyed the whole city, covering about four square miles, and the night rate was shown to be 64 per cent of the total daily rate. Between 12 o'clock midnight and 5 a. m. there was an almost smooth line of consumption. East Orange is entirely a high class residential city and it was rather startling to find that the so-called good people, wealthy people, were willing to maintain services of the kind indicated by this high night rate. After allowing what I considered to be a liberal estimate for legitimate uses, such as automatic sewer flush tanks, which fortunately we know as a positive item, and a few other positive uses, and then the legitimate house use, the balance showed that there still existed about 54 per cent of leakage. That is only a sample, I believe, of what a good many of the smaller cities would show. East Orange got its water supply from a private company for about twenty-seven years up to seven years ago, when the city bought the piping system. The plant is not old, and the mains are in excellent condition. I think some of us would do well to bear in mind the possibilities of a pitometer survey. I am not talking for the Pitometer Company at all. If there is any other concern that can do the same class of work in demonstrating this leakage, and if possible finding a means of saving the loss, there should be a large field for work. I think we should avail ourselves of this means of detecting loss and waste, unless we have an unlimited supply so that we need not care if we waste water or not.

Mr. French: What is your per capita consumption?

Mr. A. A. Reimer: Our per capita at present is about ninety-eight gallons. I will say that four years ago the per capita was about one hundred thirty gallons. When I entered into the department work at that time I found what seemed to be a rather large per capita, so instituted a house to house inspection, and inside of six months we had cut down that one hundred thirty gallons per capita to eighty-five gallons. Since then there has been an increase until at present it stands around ninety-eight gallons.

Mr. T. C. Phillips: I want to add one statement, which I think may interest you somewhat. I stated that I had surveyed about ten square miles in area of the city of Chicago. To give you some idea as to the entire situation, I want to say that the area of the city of Chicago is one hundred and ninety square miles. The territory which was surveyed lies in the central portion of the city. Perhaps one hundred and thirty-five square miles represents the built up portion of the city. We have a large area on the south and southwest side that is not built up. I want to say that I do not feel fully informed as to the entire situation in the city of Chicago, because I have not surveyed sufficiently the outlying territory, and ten square miles is hardly enough to draw conclusions from for the whole city.

Mr. Wm. Bishop: What proportion of the population does that ten square miles cover?

Mr. T. C. Phillips: Well, I should say that it probably represents from 350,000 to 400,000.

Mr. Phil Carlin: I would like to ask Mr. Reimer what per cent of the taps in the residence part of his city were running when he found that loss of 64 per cent.

Mr. A. A. Reimer: East Orange has but few meters—only about nine per cent. There are but few of these meters on residences, they being largely on small stores and boarding houses. Only about three per cent of the private residences are metered. There are six thousand five hundred services.

Table No. 1. Results of Waste Water Inspection by Water Surveys, City of Chicago, 1908

DISTRICT NUMBER	1	2A	2B	2C	2D	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21	22	[illegible]
LOCATION OF DISTRICT	LOOP — LAKE MICH. TO CHICAGO RIVER TO HARRISON ST.	HARRISON TO 12TH ST. AND STATE ST. TO CHICAGO RIVER	12TH ST. TO 16TH ST. AND STATE ST. TO CHICAGO RIVER	16TH ST. TO 22D ST. AND STATE ST. TO CHICAGO RIVER	HARRISON TO 22D ST. AND STATE ST. TO LAKE MICHIGAN	22D ST. TO 31ST ST. AND STATE ST. TO LAKE MICHIGAN	22D ST. TO 31ST ST. AND STATE ST. TO PRINCETON AVE.	HARRISON TO 14TH ST. AND HALSTED ST. TO CHICAGO RIVER	14TH ST. TO 22D ST. AND HALSTED ST. TO CHICAGO RIVER	CHICAGO AVENUE AND LASALLE AVENUE TO CHICAGO RIVER	WELLS ST. TO STATE ST. AND CHICAGO AV. TO CHICAGO RIVER	STATE ST. TO LAKE MICH. AND CHICAGO AV. TO CHICAGO RIVER	CHICAGO AV. TO RANDOLPH ST AND HALSTED ST. TO CHICAGO RIVER	12TH ST. TO HARRISON ST. AND HALSTED ST. TO MORGAN ST.	12TH ST. TO HARRISON ST AND MORGAN ST. TO CENTER AV.	MADISON ST. TO HARRISON ST. AND HALSTED ST. TO MORGAN ST.	MADISON ST. TO HARRISON ST. AND MORGAN ST. TO CENTER AV.	CHICAGO AV. TO DIVISION ST. AND ORLEANS ST. TO CHICAGO RIVER	MADISON ST. TO HARRISON ST. AND CENTER AV. TO ASHLAND BOUL.	12TH ST. TO HARRISON ST. AND CENTER AV. TO ASHLAND BOUL.	PRINCETON AV. TO HALSTED ST. AND [illegible] ST. TO CHICAGO RIVER	PRINCETON AV. TO HALSTED ST. AND [illegible] ST. TO 31ST ST.	HALSTED ST. AND 31ST ST. TO CHICAGO RIVER
DATE OF TEST { 1st Survey	Sept. '08	March '08	July '07	July '07	July '08	Aug. '08	Oct. '07	Oct. '07	Oct. '07	June '08	May '08	June '08	Oct. '08	June '08	July '08	Aug. 08	Aug. '08	Aug. [illegible]	Sept. 08	Nov. 08	Sept. [illegible]	Sept. [illegible]	[illegible]
DATE OF TEST { 2d Survey			July '08	March '08				Oct. '08	May '08					Oct. '08	Nov. '08	Nov. '08	Dec. '08				Dec. [illegible]		
1 Area in acres	720	113	94	149	310	320	258	319	304	170	125	259	155	70	90	80	80	154	160	160	164	215	[illegible]
2 Population	Floating	‡4,574	600	5,128	12,000	22,704	20,000	23,000	17,200	4,150	12,900	6,900	2,400	7,900	10,200	5,500	6,600	[illegible]	9,200	14,400	[illegible]	[illegible]	[illegible]
3 Metered supply . . . gallons per day	13,062,273	‡818,732	275,920	1,217,980	1,514,502	1,410,500	552,070	‡2,601,000	‡1,052,000	721,000	760,400	508,700	499,410	100,450	53,830	313,540	104,780	[illegible]	252,200	43,900	[illegible]	[illegible]	[illegible]
4 Unmetered supply . . . gallons per day	4,481,102	‡3,211,268	1,344,080	2,654,020	4,225,500	4,185,500	2,705,030	‡4,699,000	‡2,748,000	2,148,000	2,181,600	1,241,300	2,990,590	1,850,550	2,012,670	1,541,460	1,123,220	[illegible]	1,890,100	1,658,100	[illegible]	[illegible]	[illegible]
5 Total supply . . . gallons per day	17,543,375	‡4,030,000	1,620,000	3,872,000	5,740,000	5,596,000	3,257,000	7,300,000	3,800,000	2,869,000	2,942,000	1,750,000	3,490,000	1,951,000	2,066,500	1,855,000	1,228,000	[illegible]	2,172,000	1,702,000	[illegible]	[illegible]	[illegible]
6 Leaky plumbing fixtures (unmetered) . . . gallons per day			36,000	268,400				2,023,729	652,652		75,148			301,712	223,833	188,996	204,116				[illegible]	[illegible]	[illegible]
7 Underground leakage (estimate of 75% min. night rate) . . . gallons per day								1,100,000	880,000					528,750	585,000	581,250	474,000						
8 Net consumption [5–(7 + 21)] . . . gallons per day								3,600,000	2,040,000					475,250	452,000	460,750	317,000						
9 Gallons per capita—before inspection			2,700	755	478	247	163	318	221	691	228	254	1417	247	203	337	186	207	236	[illegible]	[illegible]	[illegible]	[illegible]
10 Gallons per capita—after inspection			2,153	535				204	170				*648	127	102	190	120				170		
11 Ratio of min. night rate to av. daily rate—before inspection	74%	95%	97.7%	92.5%	87%	76.6%	92%	99.1%	83.9%	73%	78%	75%	94.6%	87.1%	87.6%	80.2%	86.2%	86%	80.6%	[illegible]	[illegible]	[illegible]	[illegible]
12 Ratio of min. night rate to av. daily rate—after inspection		95%	97%	79%				73.5%	78.3%					70.2%	75.2%	74.3%	†80.4%				[illegible]		
13 Number of places inspected			90	419				2060	2073		185			787	1011	684	727		1294		[illegible]	[illegible]	[illegible]
14 Total number of leaky fixtures			78	269				1903	691		155			621	801	597	540		1004		[illegible]	[illegible]	[illegible]
15 Total number of underground leaks			39	108				1526	742		60			406	439	285	198		230		445	[illegible]	[illegible]
16 Annual metered revenue	$334,655.76	‡$57,311.24	$7,069.10	$31,204.67	$38,801.55	$36,136.12	$14,167.20	‡$66,009.00	‡$27,382.00	$18,473.00	$19,482.40	$13,033.28	$12,794.87	$2,573.69	$1,379.34	$8,032.82	$2,684.48	[illegible]	$7,230.65	$1,124.70	[illegible]	[illegible]	[illegible]
17 Annual frontage revenue	$8,985.70	‡$8,192.44	$991.00	$8,200.50	$15,864.00	$30,534.00	$28,236.50	‡$33,572.00	‡$20,775.00	$6,754.00	$17,554.50	$11,845.50	$5,373.00	$13,384.25	$17,517.25	$10,960.50	$11,697.50	[illegible]	$19,691.50	$22,524.75	[illegible]	[illegible]	[illegible]
18 Total annual revenue	$343,641.46	‡$65,503.68	$8,060.10	$39,405.10	$54,665.55	$66,670.12	$42,403.70	‡$99,581.00	‡$48,157.00	$25,227.00	$37,036.90	$24,878.78	$18,167.87	$15,957.94	$18,896.59	$18,993.32	$14,381.98	[illegible]	$26,922.15	$23,649.45	[illegible]	[illegible]	[illegible]
19 Revenue per 1000 gals. from metered supply	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	‡$0.07	‡$0.0713	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	[illegible]	$0.07	$0.07	$0.07	[illegible]	[illegible]
20 Revenue per 1000 gals. from unmetered supply	$0.0050		$0.0020	$0.0084	$0.0102	$0.020	$0.0288	‡$0.0196	$0.0207	$0.0086	$0.0220	$0.0261	$0.0058	$0.0198	$0.0243	$0.0193	$0.0284	[illegible]	$0.0284	$0.0371	[illegible]	[illegible]	[illegible]
21 Saving in supply . . . gallons per day		‡1,430,000	328,000	1,130,000				2,600,000	880,000				1,434,724	947,000	1,029,500	813,000	†437,000				[illegible]		
22 Saving in revenue per annum—Based on $0.029 per 1000 gals.		‡$13,043.00	$3,481.39	$11,993.82				$27,596.40	$9,314.80				$15,228.16	$10,051.46	$10,927.11	$8,629.18	$4,638.32				[illegible]		

† Incomplete on account of cold weather.

‡ Figures from 1907.

Total saving of 9,939,224 Gallons per day—made in 1908

Total savings of $105,494.92 per annum—made in 1908

While I am on my feet, Mr. President, I would like to ask for a little more information about this pump slip matter. The figures given here have always seemed high to me. I would like to know if our pump slippage is remarkable in any way at all. We seldom get a slippage of more than two per cent and often it is down to one per cent. Our pump is of the cross compound crank and fly wheel type.

President French: With an engine in exceedingly good condition, and pretty new, with new valves and new plungers, I should not think there ought to be very much more than that. There are a good many tests of engines made that show it to be around 2½ and 3 per cent on large machines. Our company has six vertical triples, the smallest ten million, and the largest twenty million; and the best test that we have made on either of these engines is down to about 3½ per cent; but I have not any doubt but that the average slippage is 5 per cent. I always feel pretty well satisfied that we can hold it down to 5 per cent.

In an engine of that size there are about 1200 valves in the chambers, and if anyone of these valves go wrong, it is enough to cause considerable slippage. In the case of a 12,000,000 gallon engine, working under 140 pounds pressure, and with one valve out in the bottom chamber, it means about one-half million gallons in twenty-four hours. Under this particular condition, a very few bad valves represent a very heavy slippage loss.

Mr. A. A. Reimer: Our pumps have been in about five years, pumping perfectly clear artesian water. The pressure is about 98 pounds.

President French; I should not think with a per capita around ninety gallons and so many without meters, that you need fear very much loss from the slippage or street main losses.

Mr. A. A. Reimer: No. But I was wondering whether our figures are exceptional in any way.

President French: We have 4000 meters in a district which perhaps compares favorably to yours. It is a residential section almost wholly. We hold the per capita down to thirty-two gallons. The district is metered throughout.

HIGH DUTY PUMPING RECORDS AT NORTH POINT PUMPING STATION, MILWAUKEE, WIS.

BY CORNELIUS T. MYERS.[1]

In 1874 the city of Milwaukee started to operate in the North Point Pumping Station the first crank and fly-wheel pumping engines built by the E. P. Allis Co. (known as No. 1 and No. 2), a pair of compound beam engines each having a capacity of 8,000,000 gal. in 24 hrs. These engines on test developed a duty of 85,000,000 ft. lb. per 100 lb. of anthracite coal, and a station duty of about 71,500,000 ft. lb. Since that time the pumping capacity of the North Point Station has steadily increased so that at the present time the total capacity of the engines in the one engine room is 86,000,000 gal. per 24 hrs., and the progress in the design of high duty pumping engines is well shown by the different types of engines there installed. It will be interesting, therefore, to review the history of this pumping station and note the progress made in the manufacture of pumping engines as there represented; and also to note some very unusual station duty results, for which too much credit cannot be given to Messrs. McMillan and Hamilton, the engineers at North Point, for the careful and systematic study of the engines under their charge, and the expert way in which these engines are handled.

Water is drawn from Lake Michigan at temperatures varying from 32° F. to 60° F. and discharged against a total head of about 168 ft. into a reservoir having a capacity of 21,500,000 gal. The suction valves of the pumps are practically at the level of the lake. A standpipe of 12,000 gal. capacity is connected to the discharge pipe line. This station furnishes the entire water supply for the city of Milwaukee, having a population of about 350,000; but another station, called the High Service Station, re-pumps from 7,000,000 gal. to 10,000,000 gal. daily from the reservoir into the higher districts of the city. The average daily pumpage from the North Point Station is

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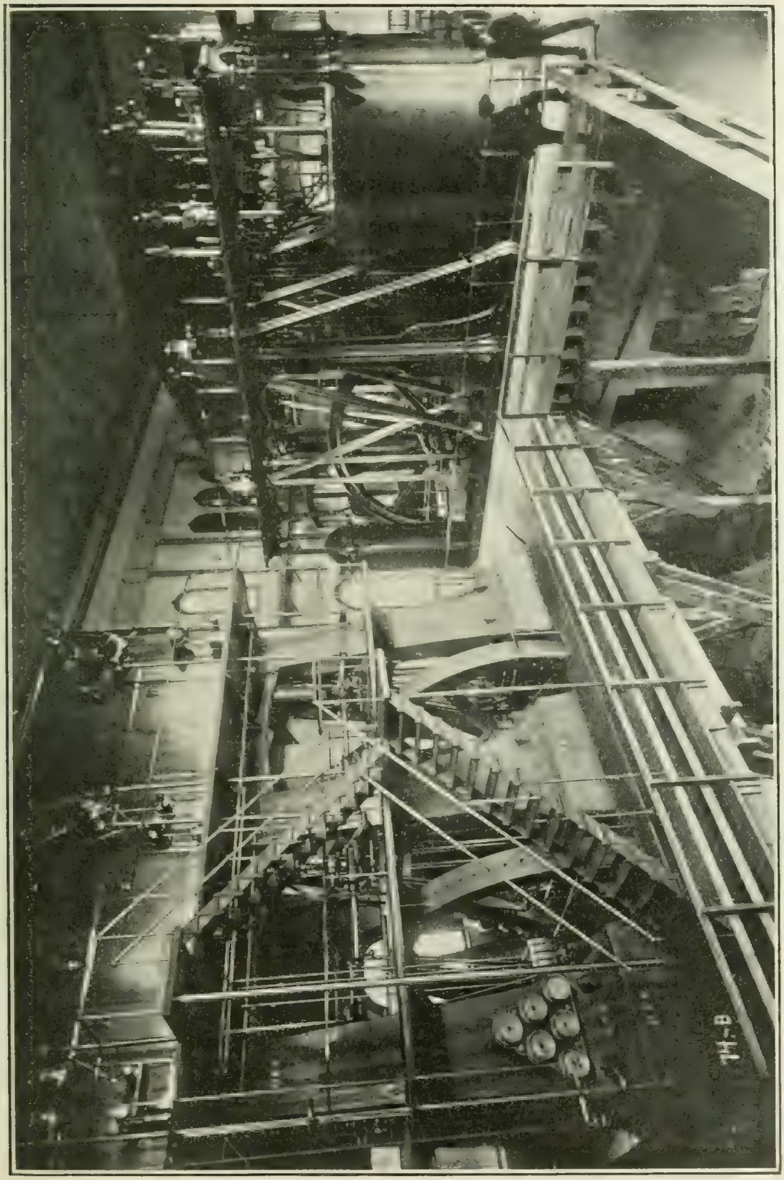
[1] Copyright 1909 by Cornelius T. Myers.



PUMPING ENGINES, NO. 1 AND NO. 5, AND PIT READY FOR PUMPING ENGINE NO. 6, NORTH POINT, MILWAUKEE about 40,000,000 gal. in summer and winter, and from 32,000,000 to 34,000,000 gal in the spring and fall of the year.

In 1882 a 12,000,000 gal. compound engine, known as No. 3, was installed. This engine showed a test duty of 104,820,431 ft. lb. per 100 lb. of anthracite coal, and after its installation the average station duty of the three compound engines was about 80,000,000 ft. lb. per 100 lb. of coal.

In 1892 an 18,000,000 gal. vertical triple expansion pumping engine, known as No. 4, was installed; and in December, 1893, Dr. R. H. Thurston read before the American Society of Mechanical Engineers a paper entitled "The Maximum Contemporary Economy of the High Pressure Multiple Expansion Steam Engine," describing engine No. 4, commenting upon the development of the high duty pumping engine as embodied in that machine, and setting forth the tabulated results of a duty test made on March 25 and 26, 1893, by Prof. R. C. Carpenter. In this paper Dr. Thurston makes the following remarks:

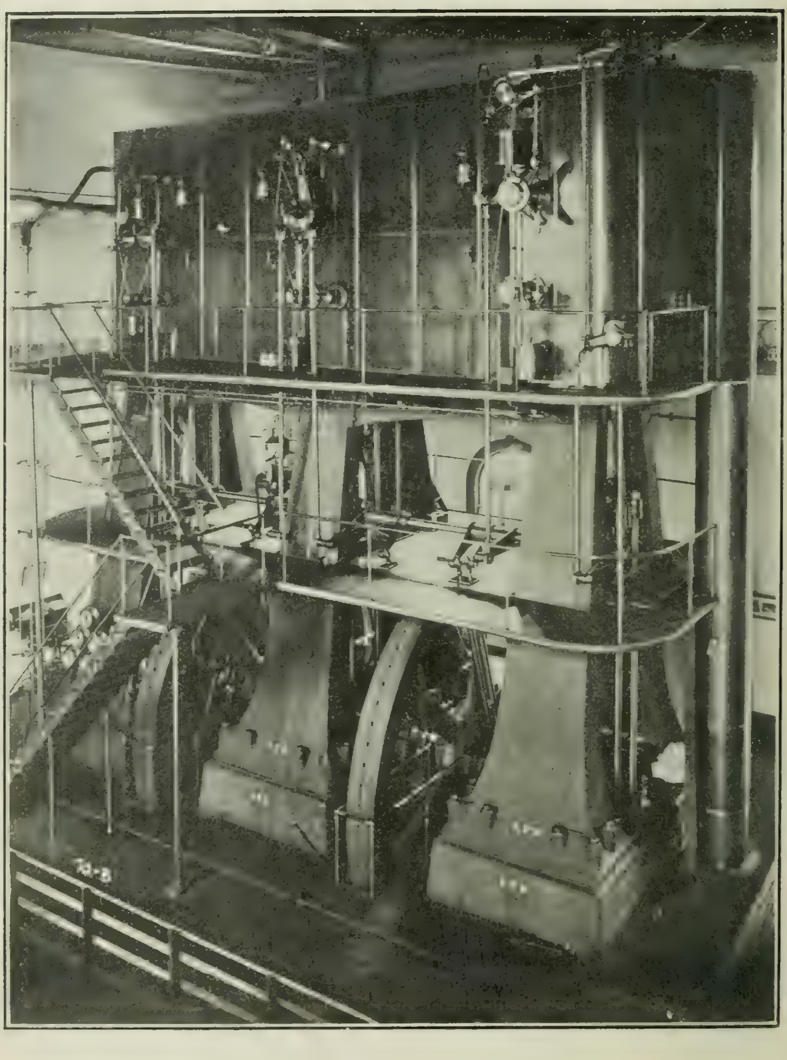
> The culmination of this century of improvement, so far as the writer is at present informed, has been reached in the case to be here reported as illustrating the maximum contemporary economy of the high pressure multiple-expansion steam pumping engine. . . . . This latest and highest record of efficiency and duty, one which may very possibly long stand as the highest record—the passage of the date at which the quantity of steam used per hour and per horse-power below 12 lb. (5.5 kilograms) constituting an important era in the history of the steam engine—is, on the customary American basis of 100 pounds of fuel, 143,306,470 ft. lb. On the old British basis of 112 lb. (1 cwt.) it becomes 152,630,000 ft. lb., and on the proposed basis of 1000 lb. of feed-water converted into dry steam, and of 1,000,000 B.t.u., it is 154,048,704 and 137,656,000, respectively. For kilogram-meters of work per kilogram of fuel, the figure becomes 429,110. These figures compared with those of the preceding paragraph [Dr. Thurston refers to the Cornish engines of Watt] will complete the record of progress to date, and perhaps indicate the limit of advance for the nineteenth century in this department of human achievement. It still leaves us a margin of 20 per cent between the ideal and the real case for further gain; the thermo-dynamic case, assuming similar pressures and ratio of expansion, demanding nearly 10 lb. of steam per horse power per hour, and giving a duty of close upon 175,000,000 on the first-named basis, and about 200,000,000 on the highest standard. The ideal and the real efficiencies correspond, respectively, to fuel consumption of 1.1 and 1.8 lb. per horse-power per hour, with good boilers.

The duty developed in this test was 135,770,000 ft. lb. per 100 lb. of Pocahontas coal, the engine pumping water at an average rate of 18,331,364 gal. per 24 hrs. against a total head of 161.8 ft. with a steam pressure of 121.45 lb. at the throttle; and the duty per 1000 lb. of dry steam was 154,084,704 ft. lb., and dry steam per hour per i. h. p. was 11.678 lb. This, as Dr. Thurston stated, was an achievement at that time.

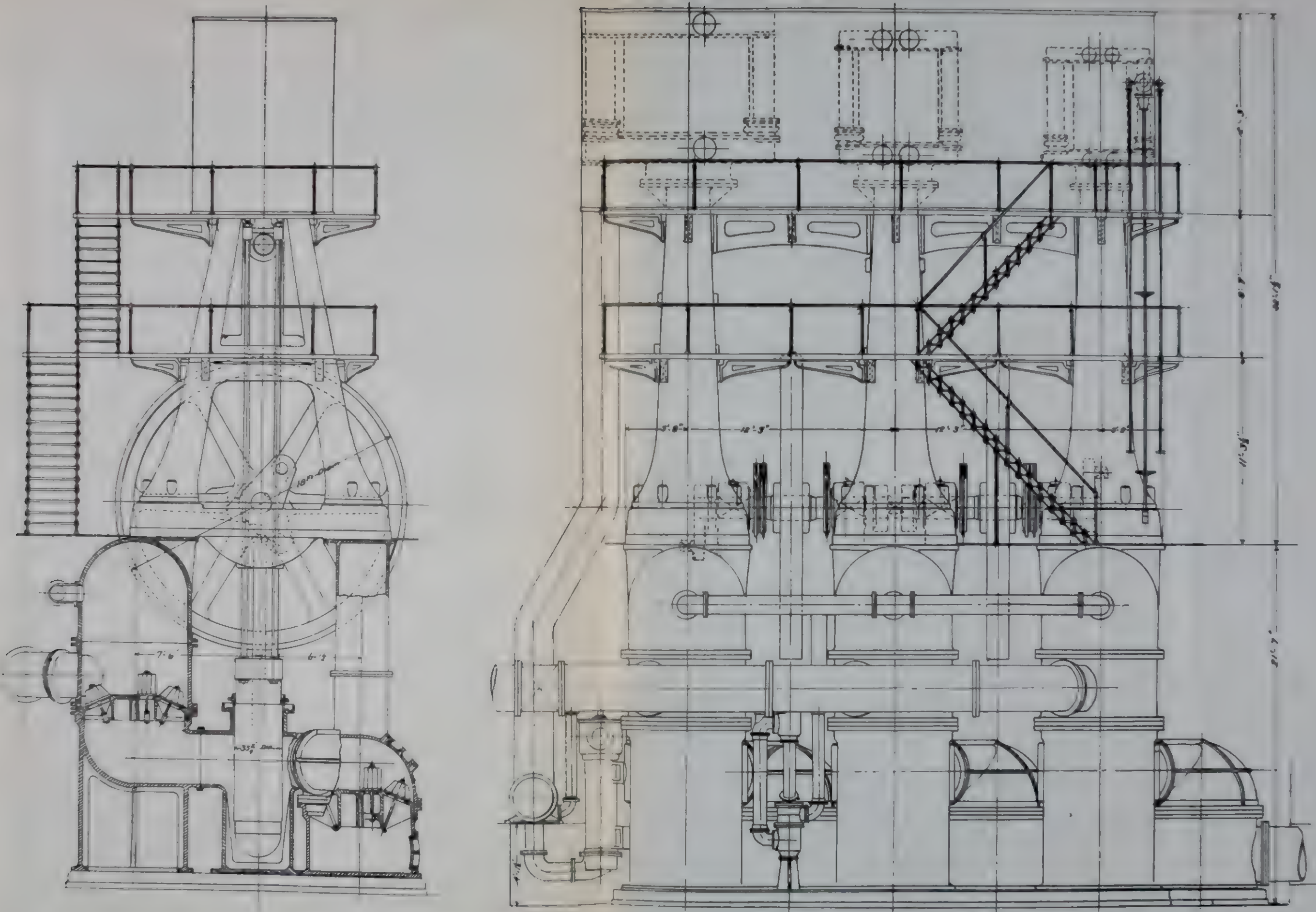
In 1906 a 20,000,000 gal. vertical triple expansion pumping engine known as No. 5 was installed in this station; and in June, 1908, engine No. 6, a duplicate of No. 5, was started. Engines Nos. 5 and 6, while of the same general type as engine No. 4, exceed by a considerable margin the duty shown by that engine; and while the official test duty of No. 5 does not equal *in figures* the best test duties attained by engines of a similar type in other cities, it is about on a par with them when the low steam pressure (123 lb.) and the low water pressure (67 lb.) are taken into consideration. As will be shown later, a very noticeable feature of the operation of the North Point Pumping Station is the relatively very *high station duty* obtained from engines No. 5 and No. 6 as compared with the test duties of these engines.

These results are perhaps worthy of study and comparison with the relative test and station duties of other engines of this type, for there is no reason why there should be any wide discrepancy between the two, unless there is some important change in the conditions of operation. As far as possible, however, the specifications for such a pumping engine should call for a duty test made under every day operating conditions; the test duty and station duty results will then act as very valuable checks, both on the builder and on the engineers who operate the engine. In the case here noted it might possibly be expected that there would be no wide discrepancy, because on the one hand the duty test was conducted by the engineers of the North Point Pumping Station under practically the everyday working conditions, and on the other hand because of the skill of these same men in keeping the engines constantly at top efficiency; but in any event credit must not only be given them for obtaining reliable data on the maximum duty obtainable under their operating conditions, but for practically maintaining this duty on their station record.

On March 6 and 7, 1907, a 24-hour duty test on engine No. 5 was made by the officials of the City of Milwaukee, Mr. Thomas McMillan, Chief Engineer of Pumping Stations, and Mr. B. W.



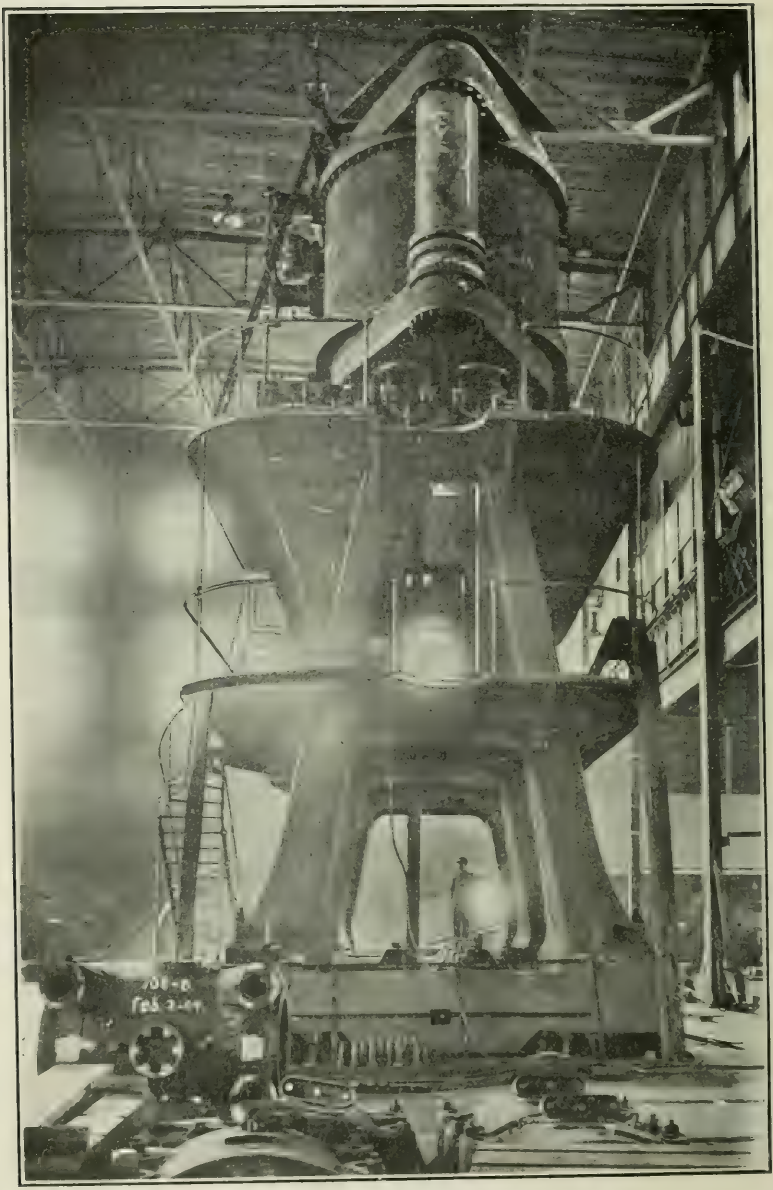
STEAM END OF PUMPING ENGINE NO. 5



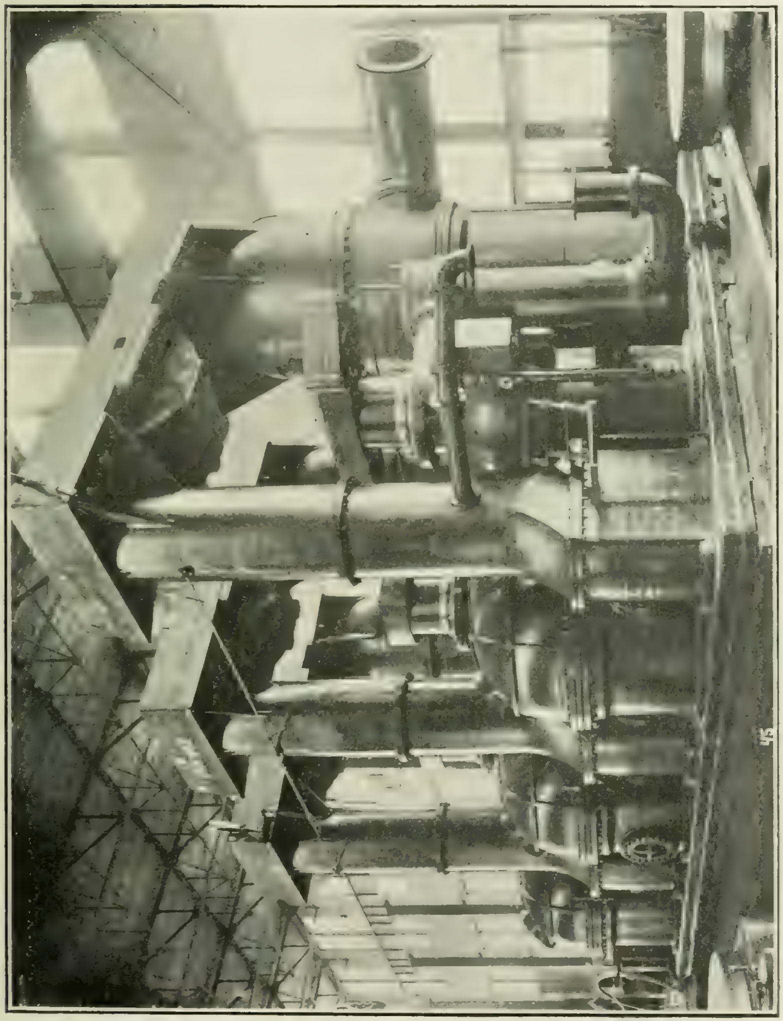
General Drawing of 20,000,000 Gal. Pumping Engine for North Point Pumping Station, Milwaukee, Wis.

Perrigo, Assistant City Engineer, being in charge. The operation of the engine was in charge of Mr. James T. Hamilton, Engineer in Charge of the North Point Pumping Station, and his assistants. Representatives of the manufacturers checked the readings taken and the log made by the city officials. The following comments and data are taken from the 1907 Annual Report of the Bord of Public Works of the City of Milwaukee:

> The specifications call for a self-contained, vertical, triple expansion, crank and fly-wheel, three plunger, condensing pumping engine, with sufficient capacity to raise and deliver 20,000,000 United States gallons of water against a pressure of 67 lb. per square inch, in 24 hours and with a steam pressure of not to exceed 125 lb. per square inch at the throttle. The engine is required to perform a duty of not less than 160,000,000 ft. lb. for every 1000 lb. of steam used; no deductions to be made for steam containing 2 per cent or less of moisture. The work performed to be based on the plunger displacement with no deduction for leakage or slippage less than 1 per cent. The net head to be determined by a gauge attached to the force main, with due allowance for the difference between the gauge and the height of water in the supply conduit, but no allowance to be made for friction through the pumps.
>
> The proposition of the makers was to furnish one triple expansion, direct connected, crank and fly-wheel, pumping engine, to pump 20,000,000 gal. of water every 24 hrs., when running at 20 r.p.m. against a pressure of 67 lb. with an initial steam pressure of 125 lb. by the gauge at the throttle and to develop under these conditions, a duty of 162,500,000 ft. lb. per 1000 lb. of dry steam.
>
> The engines and pumps are of the type and size prescribed in the specifications. The base plate rests upon the concrete foundation, which was furnished by the city, and is at city datum line, or about 5 feet below the basement floor. The engine bed plates are supported by the suction and delivery chambers and are at the elevation of the engine room floor.
>
> The three pumps are each of the single acting, outside packed, plunger type. The plungers are each 33¾ in. in diameter, making the cross sectional area of each plunger 894.62 sq. in. On the suction and discharge side of each pump is a cast steel diaphragm, containing eleven cages, eight of which contain twenty medium hard rubber valves each and three of which contain twenty-five such valves each. This arrangement provides each diaphragm with 235 3½-in. valves or 1255 sq. in. of valve area. The total number of rubber valves in the pumps is 1410. All of the auxiliary pumps are driven by means of arms attached to and projecting out from the low pressure pump plunger. The circulating pump takes the cooling water for the condenser from the suction chamber and returns it to the same source. The condenser is a surface condenser having brass tubes.
>
> The steam cylinders are supported on massive box A frames, resting on the engine bed plates. The A frames are of the marine type having bored guides. The steam cylinders, including the top and bottom heads, are



END VIEW OF STEAM END IN SHOPS



WATER END OF PUMPING ENGINE NO. 5

steam jacketed. The steam and exhaust valves are placed in the heads of the cylinders. All of the steam and exhaust valves are of the Corliss type except the exhaust valves of the low pressure cylinder, which are single seated poppet valves operated by cams. There are two eccentrics for each cylinder, one for the steam and one for the exhaust valves. The motion is transmitted to rocker arms on a lay shaft situated just above the first gallery, thence to the valve motion. The cut-off for the high pressure cylinder is controlled by an adjustable fly-ball governor and that for the intermediate and low pressure cylinders by hand devices arranged so as to be operated from the engine room floor.

The suction for the pumps is a 36 in. cast iron pipe extending down to the 5 ft. distributing tunnel of the intake, which is situated just south of the southerly wall of the engine house and is 14 ft. below city datum line. The delivery pipe is a 30 in. cast iron pipe connected to the 42 in. force main just inside of the westerly wall of the engine house. The 42 in. main is cross connected to the general distribution system at the standpipe.

The dimensions of the main parts of the engine are as follows:

Diameter of high pressure cylinder, inches	30
Diameter of intermediate pressure cylinder, inches	52
Diameter of low pressure cylinder, inches	80
Diameter of piston rods, one for each cylinder, inches	5.625
Diameter of pump plungers, one for each of three pumps, inches	33.75
Diameter of air pump, inches	24
Diameter of circulating pump	8
Diameter of feed pump, inches	2.25
Diameter of air compressor, inches	2.25
Stroke of pistons and air plungers, inches	60
Volume of H.P. cylinder (displacement less ½ rod) cu.ft.	24.11
Volume of I.P. cylinder (displacement less ½ rod) cu. ft.	73.31
Volume of L.P. cylinder (displacement less ½ rod) cu. ft.	174.10
Volume of first receiver, cubic feet	110.00
Volume of second receiver, cubic feet	200.00
Ratio of H.P. to I.P. cylinders	1:3.04
Ratio of I.P. to L.P. cylinders	1:2.37
Ratio of H.P. to L.P. cylinders	1:7.22
Ratio of H.P. cylinder to first receiver	1:4.56
Ratio of I.P. cylinder to second receiver	1:2.72
Ratio of first receiver to second receiver	1:1.82
Heating surface, first receiver coil in square feet	60
Heating surface, second receiver coil in square feet	80
Cooling surface in condenser in square feet	1050

The test was started March 6 at 11 o'clock a.m. and continued through until March 7 at 11 o'clock a.m. All gauges were calibrated before and after the test and found correct. The water pumped was determined by the plunger displacement. The pumps were tested for leakage before the test run was started and found to be in good condition, having only a few minute leaks in some of the pump valves, also in some of the joints.

The percentage of moisture in the steam was determined by a separating calorimeter placed in the main steam pipe just above the main header over the boilers.

All gauges were read every fifteen minutes. Indicator cards were taken from each end of each cylinder on an average of every two hours and from the water end on an average of every three hours.

The tabulated result of our test is as follows:

Duration of test	24 hrs.
Total number of revolutions	29,604
Average revolutions per minute	20.558
Piston speed per minute, feet	205.58
Steam pressure deducting 10.96 lbs. for a column of water 25.33 feet high in the gauge pipe, pounds.	123.20
First receiver pressure, deducting 8 pounds for a column of water 18.48 feet high in the gauge pipe.	29.55
Second receiver pressure, deducting 8 pounds for a colume of water 18.48 feet high in the gauge pipe	3.26
Average vacuum, by gauge, in inches	28.35
Water pressure, in feet, per gauge	130.37
Water pressure gauge above city datum line	25.93
Water in suction conduit, in feet, below city datum line	1.576
Total average head of water in feet	157.876
Temperature of water pumped in degrees Fahrenheit	34.
Weight of water at 34° F. per cubic feet in pounds	62.42
Displacement of plungers per revolution in pounds	5815.86
Displacement of plungers per revolution in U. S. gallons	697.107
Displacement of plungers per revolution in cubic feet	93.189
Total water pumped in pounds	172,202, 323.44
Total water pumped in cubic feet	2,758,767.156
Total water pumped in U. S. gallons	20,637,155.628
Total foot pounds of work	27,186,614,015.41344
Total water received from condenser, in pounds	167,468.5
Duty of engine in foot pounds, per 1000 pounds of steam as per specifications	162,338,672.
Percentage of moisture in steam	1.384
Percentage of dry steam	98.616
Water for condenser in pounds, allowing 2317.76 lb. for 1.384 per cent of moisture in steam	165,150.74
Duty of engine, in foot pounds, per 1000 pounds of dry steam, as per guarantee of makers	164,616,967.
Average indicated horse power, H.P. cylinder	176.54
Average indicated horse power I.P. cylinder	180.424
Average indicated horse power, L.P. cylinder	257.237
Average total indicated horse power	614.201
Delivered horse power	572.109
Friction horse power	42.092

Friction horse power, per cent	6.853
Wet steam, per I.H.P. per hour, in pounds	11.36
Dry steam, per I.H.P. per hour, in pounds	11.20
Wet steam, per D.H.P. per hour, in pounds	12.20
Dry steam, per D.H.P. per hour, in pounds	12.03

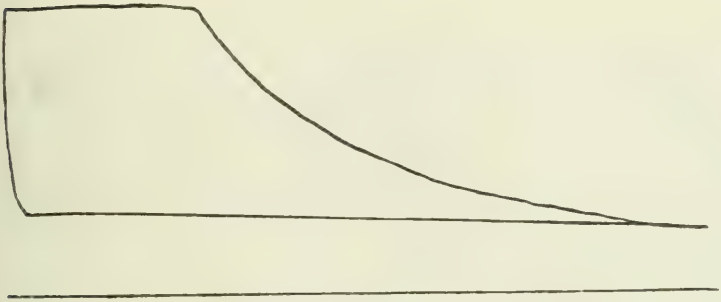
Respectfully submitted,
THOMAS McMILLAN,
Chief Engr. Pumping Stations.

B. W. PERRIGO,
Assistant City Engineer.

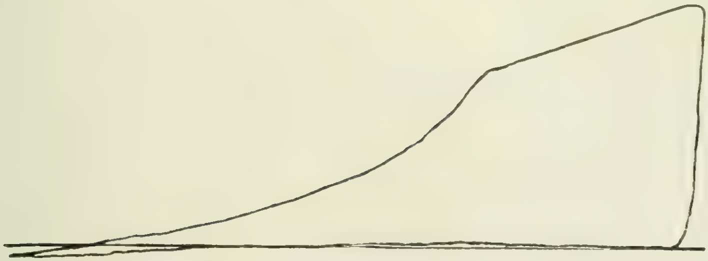
The calorimeter mentioned in the above report was located at the main boiler header, and as the steam main from this header to the throttle valve is some 35 ft. long, though covered, it contributed an additional percentage of moisture to steam actually delivered to the engine by at least ½ of 1 per cent, which would further increase the duty per 1000 lb. of dry steam to 165,440,052 ft.-lb. and decrease the steam per hour per i. h. p. to 11.145 lb.: economies not to my knowledge equalled under similar conditions. As there was no separator in the steam main the allowance of ½ of 1 per cent is very conservative, for tests made on installations of a similar character show a total moisture as high as 4 per cent. Of this 4 per cent, from 3 per cent to 3½ per cent is usually extracted by the separator and the remainder measured by the calorimeter, as this instrument fails to account for a large percentage of the *entrained* moisture although the moisture *in suspension* is easily measured.

The test was made after the engine had been in service about six months, and though the engine was stopped for minor adjustments before the test was made, it was not deemed advisable to change the valve setting to get a better steam and load distribution than is shown by the indicator cards and given in the tabulated results.

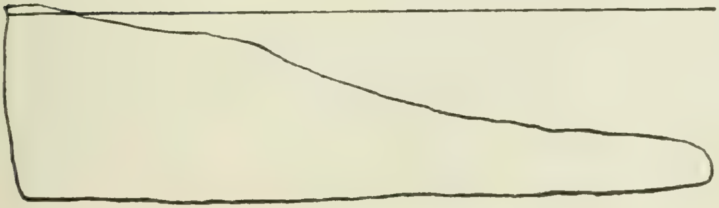
At the last analysis, however, *station duty* is the figure to which we look as the true indication of the value of the high duty pumping engine. Test duties, while they are of great value because of the complete and detailed data obtained, offering opportunity for engineering analysis and research, are of but secondary importance to the corporations which must operate the engines. The coal bill for the actual services rendered day by day and year after year is the criterion by which the value of



HIGH PRESSURE INDICATOR CARD



INTERMEDIATE PRESSURE INDICATOR CARD



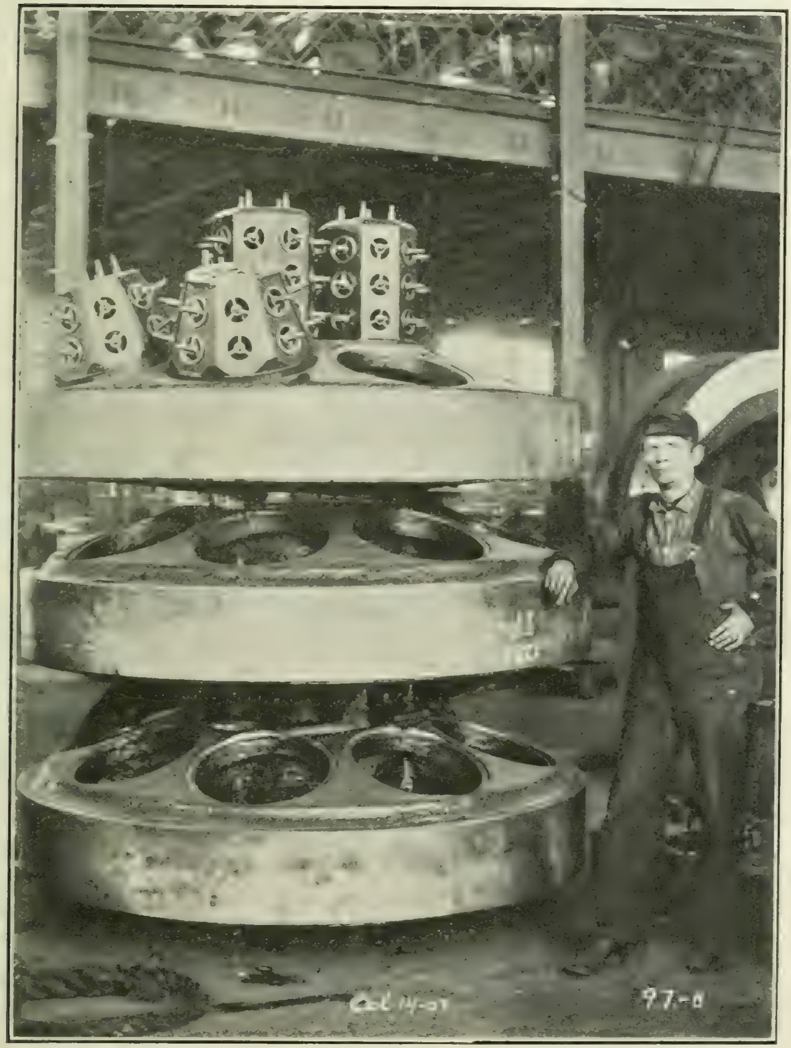
LOW PRESSURE INDICATOR CARD

these complicated and costly engines must be measured. There are pumping stations where are installed engines which on *test* show very remarkable duties, but the *station duty* as shown by the daily log fails to reveal a relative saving in the coal bill. It is of interest therefore to take from the log of the North Point Pumping Station the data necessary for computing the station duty of engine No. 5.

In the week ending September 14, 1907, 145,200 lb. of Pocahontas mine run coal were burned under the south battery of boilers, which, by the way, are not in as good condition as when Professor Carpenter made his test thirteen years before, the average factor of evaporation now being but 8.25, and the performance of the engine is therefore the more creditable by comparison. The engine ran at an average speed of 20.27 r.p.m. and delivered water at the average rate of 20,347,000 gal. per 24 hrs. The steam generated by these boilers also supplied a vertical high speed engine, which furnishes light for the station, and a slide-valve engine which furnishes power for the machine shop which is a part of this station. The average duty of the engine for the week, without deducting for the steam used by the high speed and slide-valve engines was 132,303,000 ft. lb. per 100 lb. of coal, which is equivalent to 160,038,000 ft. lb. per 1000 lb. of moist steam. If 2 per cent is allowed for the average moisture, the station duty of this engine per 1000 lb. of dry steam becomes 163,236,000 ft. lb., which is within $\frac{8}{10}$ of 1 per cent of the test duty. The two small power engines take about 2 per cent of the total steam generated, but no credit has been given to the pumping engine for this item, as part of the heat value of this steam is returned to the boilers by raising the temperature of the feed water.

Engine No. 6, a duplicate of No. 5, was first started on June 20, 1908, and as an indication of the perfection which has been attained in building and erecting machinery of this type it is worthy of notice that within thirty minutes after steam was first turned on to warm up, the engine was not only started, but took its full load, delivering water to the reservoir; and since that time it has been in regular service, the station log showing runs as high as 168 hrs. per week and pumpage rates as high as 22,500,000 gal. per 24 hrs.

For the week ending August 1, 1908, all the water for the



CAST STEEL VALVE DECKS, ENGINE NO. 6, SHOWING VALVE CAGES AND VALVE SEATS city was pumped by engines No. 5 and No. 6, each engine running 168 hours. The *station duty*, without deducting for the coal chargeable to the high speed and slide-valve engines, is easily figured from the following data:

Total pumpage	280,528,560 gal.
Average head	168.2 ft.
Steam pressure	125 lbs.
Vacuum on Engine No. 5	27 in.
Vacuum on Engine No. 6	26½ in.
Average R.P.M. No. 5	21.13
Average R.P.M. No. 6	18.8
(This engine was run slow at night.)	
Total coal burned	303,900 lb.

The station duty over a continuous run of 168 hours by two engines pumping at varying rates (at times 15 per cent above and again 15 per cent below the rated capacity for which they were designed to give maximum efficiency) was 129,490,655 ft.-lb. per 100 lb. of coal, without allowing for the coal chargeable to the small engines. The average factor of evaporation of the boilers is about 8.25 lb. of coal per pound of steam evaporated under working conditions, and taking the entrained moisture as only 2 per cent, the *station duty* per 1000 lb. of dry steam becomes 160,097,000 ft.-lb. and 11.43 lb. of dry steam per hour per i. h. p., assuming the average friction of the two engines at but 7½ per cent. The combined station duty of these two pumping engines, one of which had not been in service 30 full days, is within 2¾ per cent of the duty developed on the trial test of engine No. 5, and within 1½ per cent of the test duty guaranteed by the builders—results not to my knowledge approached elsewhere.

It will also be noted that the vacua were considerably below that gotten on the test of No. 5—this due to the high temperature of the condensing water caused by an on-shore wind which drove the warm surface water around the intake cribs, and some defective construction in the condenser on engine No. 6. A number of runs made with varying degrees of vacuum show that for an increase in vacuum from 26½ in. to 28 in. the duty is augmented by amounts varying between 2,000,000 to 3,500,000 ft. lb. per 1000 lb. of steam; no credit has been allowed for this, however.

The writer expected to be able to set forth here the tabulated results of the duty trial test of engine No. 6, but due to a long siege of trouble with a condenser that did not come up to requirements and failed to give a satisfactory vacuum, the test was delayed several months—too late to be included. The results, however, were highly satisfactory both to the city officials who ran the test, and to the builders, the duty per 1000 lb. of steam (without allowance for moisture) being over 167,000,000 ft. lb.

Within the last year the north battery of boilers has been moved to make room for two more pumping engines of the vertical triple expansion type. Each engine will have a capacity of 12,000,000 gal. per 24 hrs., but will pump directly into the high service mains against a head of 275 ft., which should enable it to give a noticeably higher duty because of the reduction in the friction which is noted as the head increases. The first of these high service engines, No. 7, has already been contracted for and is being built. The steam cylinders are 30 in. and 54 in. and 80 in. in diameter, the water plungers are 26½ in. diameter, and the common stroke of all is 60 in. When engine No. 7 and engine No. 8 are installed the total pumpage capacity of the station will be 110,000,000 gal. per 24 hrs. with all engines operating at their rated speeds; 125,000,000 gal. could be pumped by these engines, however, if there was any necessity for this pumpage.

Milwaukee can well be proud of its North Point Pumping Station and the results there accomplished, and it will furnish information both interesting and instructive to those who have the time and inclination to study its history and records.

DISCUSSION

Vice-President Alvord (In the Chair): This paper is of especial interest to those of you who are studying station economy. I understand from the program that we shall have an opportunity tomorrow of seeing these engines when visiting this pumping station, a station which is known as one of the banner pumping stations in this country. Is there any discussion of this paper, or questions?

Mr. G. H. Benzenberg: I wish to say a word to emphasize a point in connection with what the author has brought up in regard to station duty. There is perhaps no other pumping plant in the country at which more care and attention is given to the pumping machinery by the engineers in charge than at this station. You may erect the very best and highest type of pumping machinery in a station, yet if it is not operated by skilled and competent men you will not get the results that you would otherwise; and that fact is emphasized in this instance, in that the very best men, both Mr. Hamilton and Mr. McMillan, the chief engineer, have been employed continuously from the time the station was opened to the present day. a period of thirty-seven years. That fact speaks for itself as to what this station is doing and who the men are that have been entrusted with its care, and who have been retained in their positions only because of their competency.

FIRE WASTES

HERBERT M. WILSON

Chief Engineer Technologic Branch, U. S. Geological Survey

The Technologic Branch of the United States Geological Survey, which is charged with the investigation of the structural materials of the country looking toward more accurate data concerning the strength and fire-resisting qualities of the materials that go into the buildings owned by the government, has had its attention directed frequently to the enormous fire losses in the United States in comparison with those suffered in European countries.

In order to satisfy itself as to the accuracy of the statements appearing in the public press and the insurance papers of the country, a general inquiry was instituted by the Technologic Branch into the total fire waste in the United States for 1907, the cost of additional water supplies due to protection from conflagrations, the maintenance of fire departments, the payment of insurance premiums (less benefits returned), protective agencies, etc. The results obtained from this general investigation, covering practically evey city in the United States, proved that the figures of the Fire Underwriters were not exaggerated, but were even less than the actual cost.

While you are interested in the water works phase of this question, it is interesting to note that the total cost of fires in this country in 1907 amounted to more than $456,485,000, a tax upon the people exceeding the total value of gold, silver, copper and petroleum production of the United States for that year. The actual fire loss due to the buildings and their contents being destroyed amounted to $215,000,000, or a per capita loss for the entre United States of $2.51.

The significance of these figures is realized when it is known that the per capita loss of the six leading nations of Europe amounted to $0.33 per capita. The insurance loss in the United

States for the year amounted to $145,000,000, being a difference between the total premiums paid on policies, $260,000,000, and the benefits paid to the insured, $140,000,000. The cost of fire department maintenance and interest on capitalization amounted to $44,000,000 of the total. Private fire protection for the year amounted to about $18,000,000. The total cost for the year 1907 is swelled by the amount invested in city water supply services and distributing systems primarily necessary on account of fire protection, and over and above that estimated as necessary for domestic consumption. This includes interest on capital invested in city fire protection, $9,826,800, and maintenance charges, $8,465,500, the sum of which aggregates about 22 per cent of the total cost of city water supply. The depreciation charges and taxes on the above amounted to $15,167,500.

The total cost of the water works systems of the United States amounted to $1,129,247,532, the total amount chargeable to domestic service is $883,575,856, and the amount chargeable to fire service $245,671,676. In these systems the total tons of pipe used amounted to 7,097,800, of which 5,080,873 tons were used for domestic service and 2,016,927 for fire service. The total number of hydrants amounted to 420,394 and the number of hydrants in fire service was 350,152. The cost of hydrants for fire service was $29,761,400 and the value of established or contemplated high-pressure fire systems amounted to $22,191,388.

Realizing that the total loss from fires due to destruction of property involved but a fraction of the total loss of structural materials and property values due to the necessity of combating fires, a thorough study of the cost of the additional water supplies was undertaken. Five thousand seven hundred blank reports were mailed to engineers and superintendents of water works in an endeavor to obtain information regarding each plant with respect to the cost of construction, amount chargeable to domestic service, amount chargeable to fire service, etc. Fifteen hundred replies were received, only a small per cent of which were complete enough for use in tabulation. The total cost of such water supplies was therefore extracted from the Census Reports on Municipal Finance of cities over 30,000 population owning water works. The data for cities under 30,000 population was obtained from the Spectator's Year Book.

The total cost of water works systems in the United States as thus derived was segregated to show the total cost in each of five geographical divisions of the United States, viz:

Middle and New England States,
Southern and Southeastern States,
Central States.
Rocky Mountain, or arid region,
Pacific Slope States.

The total cost of the water works system in each of the geographical divisions was then subdivided to show the total cost in cities according to the following classification:

Population of 100,000 and over,
Population of 30,000 to 100,000,
Population of 5000 to 30,000,
Under 5000.

This same plan of classification was pursued in tabulating reports received from engineers and superintendents who gave detailed information sought. This information for each geographical division and classification by size of cities was then applied to the total cost of water works systems for the corresponding geographical division and classification by sizes of cities, and the same preparation and distribution made for the various inquiries.

Statistics gathered show the additional cost necessitated by fire protection. These reports are not based on the idea that water works are constructed for two purposes of equal importance, viz: domestic water service and fire-protection service; nor upon the proposition of what it would cost to construct water works systems for protection from fire alone; but rather with the idea of showing how much additional expense was incurred in cost of construction in order to secure ample protection against conflagrations. Viewing the matter from another standpoint, viz: what per cent of the cost of construction of water works should be legitimately chargeable to domestic service and what per cent to fire protection service, it is the generally accepted opinion of engineers that the cost should be equally divided except in larger cities, where a much greater per cent should be charged to domestic service.

The division into geographic districts is important because of the different conditions existing in different parts of the country. For instance, in the New England and Middle States in recent years much consideration has been given the subject of increased water supply for fire protection, including separate high-pressure service systems. Throughout the Southern States this feature has been little considered, while in the arid regions requirements of domestic supply on account of irrigation preponderates to such an extent that practically none of the water supplies had consideration on account of fire protection, the magnitude of the domestic supply being sufficient to take care not only of an ordinary fire but also conflagrations. The latter condition is true to a less degree in the case of cities of over 100,000 population, which is the reason for the tabulation being discussed not only by geographic distribution but also by population.

Finally, the outcome of this discussion indicates that whereas in the meetings of water works associations and in a few published papers bearing on the subject it has been often assumed that the additional cost of water supply on behalf of fire protection may run as high as 40 to 60 per cent, this inquiry indicates that in the average for the whole United States, 22 per cent of the total expenditure on behalf of public water supplies, or less than one-fourth of the total cost of water works systems is due to the additional supplies necessary for protection against fires of such magnitude as may be propagated beyond the building of origin. This extra cost includes 2,000,000 tons of metal having a value in excess of $127,000,000 and the metal in 350,000 hydrants having a value of $30,000,000; all of which is wasted on account of a need of preparation to fight fires, which, because of the inflammable character of building construction in this country, would develop into conflagrations without adequate water service and fire departments. The range in additional cost of water works systems due to fire protection is found, after careful discussion of the most accurate data received, to be from practically zero up to 60 per cent in certain classes of small modern cities.

In connection with this inquiry certain statistics as to the per capita cost of water works systems in cities is of considerable interest. In cities of 100,000 and over, $32.72; in cities from 30,000 to 100,000, $29.06; in cities from 5000 to 30,000, $23.60;

in cities under 5000, $16.59. The statistics showing the per capita cost of water works systems according to geographic districts is also interesting. In the New England States, $32.19 per capita; Central States, $20.35; in the Southern and Southeastern States, $19.34; in the Rocky Mountain and Western States, $63.77; and in the Pacific Slope States, $28.96.

The total cost of water works (construction and equipment) chargeable to fire service is shown to be $245,671,676, of which the source of water supply cost $66,482,220; the distributing system, 2,016,927 tons of metal, $127,236,668; hydrants, 350,152, $29,761,400; and separate high-pressure service, $22,191,388. This makes up the total cost of construction and equipment chargeable to fire service; the total annual expenses of water works chargeable to fire service, including depreciation and taxes $10,563,881, interest chargeable $9,826,867, and maintenance $8,465,487, making a total annual expense due to fire service of $28,856,235.

VICE-PRESIDENT ALVORD: We are all very much interested in this bird's-eye view of some of our responsibilities as Water Works men. It has been very interesting to me indeed. Are there any comments upon the paper?

DISCUSSION

MR. H. W. WILSON: Mr. Chairman and Gentlemen: When your secretary invited me to address you on "Fire Losses," I was pleased at the opportunity to comply with his request; first, because the subject is one regarding which there seems to be but little interest and little knowledge in this country outside of insurance circles; secondly, because I felt sure that I would have as an audience a group of professional men who would take a deep interest in a subject of such great importance. I hope, therefore, I may have the good fortune to enthuse you in proportion to the extent to which I have been enthused in what has appealed to me as a very interesting subject.

I hope members of this Society will have the opportunity to come into closer contact with this subject and that they will try as I am in my humble way, to impress upon the people of the United States the faulty, almost criminal condition of our building and construction in the cities of the United States.

The annual fire waste in the United States equals the real value of any one of the states of Florida, Idaho, Delaware, Maine, or half a dozen other states. If any one of these states were devastated by a storm which would wipe out every particle of real property, the whole world would throw up its hands in horror at such a condition; yet every year, merely because it is distributed throughout the year, we take no thought of the sum total of these terrible catastrophes by fire.

MR. H. F. DUNHAM: It may seem unfair to mention first a statement from page 91 of this interesting paper, but early attention ought to be given in any discussion to "the generally accepted opinion of engineers" that the cost of domestic supply and fire protection "should be equally divided except in larger cities." Passing over the apparent fact that engineers furnished a large part of the information upon which the author has based his own conclusions, let us note what actually occurs with respect to fire protection in a small city, for it will be an index of some of the occurrences in a larger one.

The installation of a typical water supply comprises say, pumping machinery with two or three miles of force main, the distribution system, hydrants, etc. Provision is not made "to secure ample protection against conflagrations," if ample means full or complete. Engineers realize that every city is now and has always been without such protection. The mere fact that no one would be surprised to hear of a conflagration in London or Paris or Philadelphia is ample evidence.

But to return to the typical city. Good engineering has made reasonable provision for fire protection and continued growth. There are suitable pumps, large mains and the correct number of hydrants. The number of consumers increases rapidly and all goes well until 5:30 on a hot day, when the superintendent gets word from a taker out in the suburbs where the ground is seventy feet or so above the general level, that fixtures do not supply water on the upper floors of his new apartment building. The superintendent calls his engineer to find out the cause of low pressure but the engineer says the pressure is the same it has been every day for five years, and that evening takes along his recording gage chart to prove it. At that conference trouble begins. They think nothing of it, but the next afternoon the machinery is working against five pounds more pressure than ever before, except when furnishing fire protection. The next season two or three pounds more are added and maintained through a longer period. The coal bill is not only larger but out of proportion to the quantity of water supplied.

Here let us stop a moment with this everyday incident and in imagination do something fortunately quite impossible by any other method.

The total tons of pipe amount to 7,097,800, of which 5,080,873 are for domestic use. As it is not a large city, more than two-sevenths of our typical pipe system is for fire protection. Then because of the approximate relation of pipe weights to pipe diameters we can for domestic use at once reduce every six-inch pipe, the smallest in the distribution system to four-inch—every eight to six—every twelve to ten—every twenty-four to twenty—every thirty-six to thirty, etc. Would the engineer know something had occurred? How would the trustees regard the next year's fuel bill? Every year the population increases at the average rate for the United States. Presently the friction in the shrunken distribution system will increase fuel bills by an amount equal to the interest, at municipal rates, upon a good part of the difference in cost between a distribution system for domestic use and one for both domestic use and fire protection. The illustration would persuade the author of the paper that the 2,000,000 tons added to distribution systems for fire protection are not all fire wastes.

Municipal authorities are not so apt to be extravagant where their work is to be invisible to the public. There may even be difference of opinion about the capacity of the average system for domestic use alone. It is well known that many systems are too small for economic service in supplying the quantities of water now furnished daily. (The quantities are absurdly large, but that goes into another list of wastes.)

As it becomes known that modern well-coated cast iron pipes in many different states and localities remain practically unchanged for a third of a century, we can think of a life period for such pipe of a century or two. The interval of a few years, speaking comparatively, in which distribution systems smaller than those we have could serve a good purpose for domestic use, is worthy of notice, but not of any exaggeration. The relative proportions of extra expense for fire protection are constant. The typical city passes presently into the list of cities using steamers, for the chance of bursting a main involves too much risk and then to the list of those larger cities "where a much greater per cent should be charged to domestic use."

The same analysis may be carried to the machinery. For domestic use high duty, expensive pumps are necessary and to insure pressure at all times there must be duplications as to capacity, but not in cost, for cheaper machines can be held in reserve for domestic use and for fire protection too during the period of direct pressure in a particular city. Thus the writer is constrained to believe that hundreds of millions "chargeable to fire service" should be greatly reduced. The author of "Fire Wastes" is entreated to note the extent to which his inquiries and replies have led him to call a permanent and increasingly valuable instrument a "waste," where facts point to a low and decreasing rate of interest upon that investment as the correct measure of the real waste due to fire protection.

Can the statement relating to hydrants be sustained? Before the typical plant was long in operation the mains needed flushing and after far away blow-offs had been opened, the hydrants, four or five at once and in order, were also opened and the principal lines of mains flushed, progressively, better than could have been done in any other way. A little later the sewer system was built and much puddling and back filling was done giant nozzlewise from the hydrants. Then followed paving on a concrete base and further paid for use of hydrants under permission of the trustees, of course. There was to be a parade and the previous night it occurred to somebody to wash up the pavement, which was done from the hydrants. The result was so satisfactory that afterward in hot weather once or twice per week, the same washing and flushing was repeated; keeping down the dust and to some extent the great white plague, hardly less important than use of hydrants for fire protection.

About this time the new mayor refuses to let the M. I. Railway occupy one of the city streets and the council sustains him. The railway manager mentions a state charter, a land grant in Idaho—states and Federal authority—and no third-class city shall stop him. He rushes in a large force. The mayor gets the constable, quietly lays lines of hose, orders the pressure up, and bursts around the corner with half a dozen good streams. An incipient riot is treated in a similar manner. All this shows the variety in the domestic use of hydrants. The use, including the necessary flushing of mains and washing of streets may be estimated as more than half of the total use having regard to the quantity of water furnished. It affords good reason for dividing the $29,761,400 in like proportion. It will not fit the occasion to say that 70,000 hydrants are for domestic use and 350,000 for fire protection. Aside from the modern high pressure systems, any hydrant is subject to domestic use and for purposes not to be served by any construction very different from a hydrant. That is, there must be connection with the force main; there must be capacity; there must be convenience of control and the first cost would not vary greatly whether a four or six or three inch connection were made. The device is known commercially as a fire hydrant. Had it been called a fire and water hydrant, its relation to fire wastes might appear less conspicuous.

After the first shock on hearing that a liner has been driven ashore, one may think of possible salvage. As we begin to recover from the surprise due to the mention of the annual loss of $215,000,000, we may again venture to think of salvage. Is there any? Can a more cheerful view be fairly defended?

Every year in this country a vast number of buildings are demolished at great cost and usually to make room for structures of greater cost. The total number or value of buildings so destroyed must approach that of buildings destroyed by fire and may be even greater. This being accepted from our observation if not by our records, it must follow that many buildings which are burned down would be torn down within a comparatively short time if the fires had not occurred. In fact it not infrequently happens that after a large fire real estate in the burned over district appreciates and sometimes it is worth quite as much as both real estate and buildings were worth before the fire occurred. Facts like these ought not to be overlooked when it is well known that fires are more likely to originate and be destructive in the class of buildings which the country can best afford to lose and the people are most anxious to see replaced by more expensive and durable structures.

Now, what is the effect of this item if introduced as a factor in the complex problem? If we can clearly perceive that in a large number of cases there are certain to prevail as the result of fires, conditions much better than those that would have prevailed without the fires and the insurance, we must admit that the loss to the country is not fairly represented by the figures set forth as fire losses.

A large forest well illustrates the more encouraging outlook. In a severe driving storm many trees are prostrated and great injury is apparent. Upon closer examination it is found that here a prostrate trunk is hollow; another was not well rooted; a third had been weakened by insects, while around each one younger and sounder trees that had been deprived of sunlight have a chance to grow. Individual trees suffered. The forest as a whole suffering, but less than we imagined at first. Individuals suffer from fires; the country suffers, but hurts are healed more rapidly because of the progressive tendencies of the people, new methods employed and the superior final results.

Are our carelessness and want of forethought in construction, compared with those of other peoples in the ratio of \$2.50 to \$.33? Is this implied by the high "significance" as used by the author?

There is a great difference in the conditions at the ends of that part of a great circle of the earth which lies between the mouth of the Rio Grande River and Kane Basin. In certain months of the year anywhere along a thousand miles of the south part of that land, one may suddenly experience a sense of suffocation and feel full assurance that the adjacent building is on fire. If he touches the outer wall of the building he is in he will be equally certain the fire is in that building. He may endure the withering heat for days and nights while vegetation becomes crisp and the air is like that from a furnace. Nothing similar to this occurs around Kane Basin. The outer walls of the buildings there are said to be always cool.

The geographical center of the area occupied by the six leading nations of Europe, if transferred to our imaginary circle would fall near Lake Winnipeg or Hudson Bay. The average temperature, rainfall, snowfall, fogs, etc. would not be identical with those in our own country. We cannot move our country to the North to escape the fire risks incident to a scorching sun and a dry atmosphere.

The buildings in most foreign countries differ greatly from ours, in part because of the higher latitudes and also on account of customs and period of settlement. Shall we hasten to adopt the thick rubble wall, low ceiling, small dormer windows and few of them, bad ventilation and absence of sunlight that even in England help confirm Parliamentary doubt as to the sturdiness of present-day soldiers?

It is impossible to estimate the comfort and value to the people of the generous use of timber, lumber and glass in this country. Enormous and vital interests are involved, compared with which the loss per capita per annum from fires is an important but minor item.

THE STERILIZATION PLANT OF THE JERSEY CITY WATER SUPPLY COMPANY AT BOONTON, N. J.

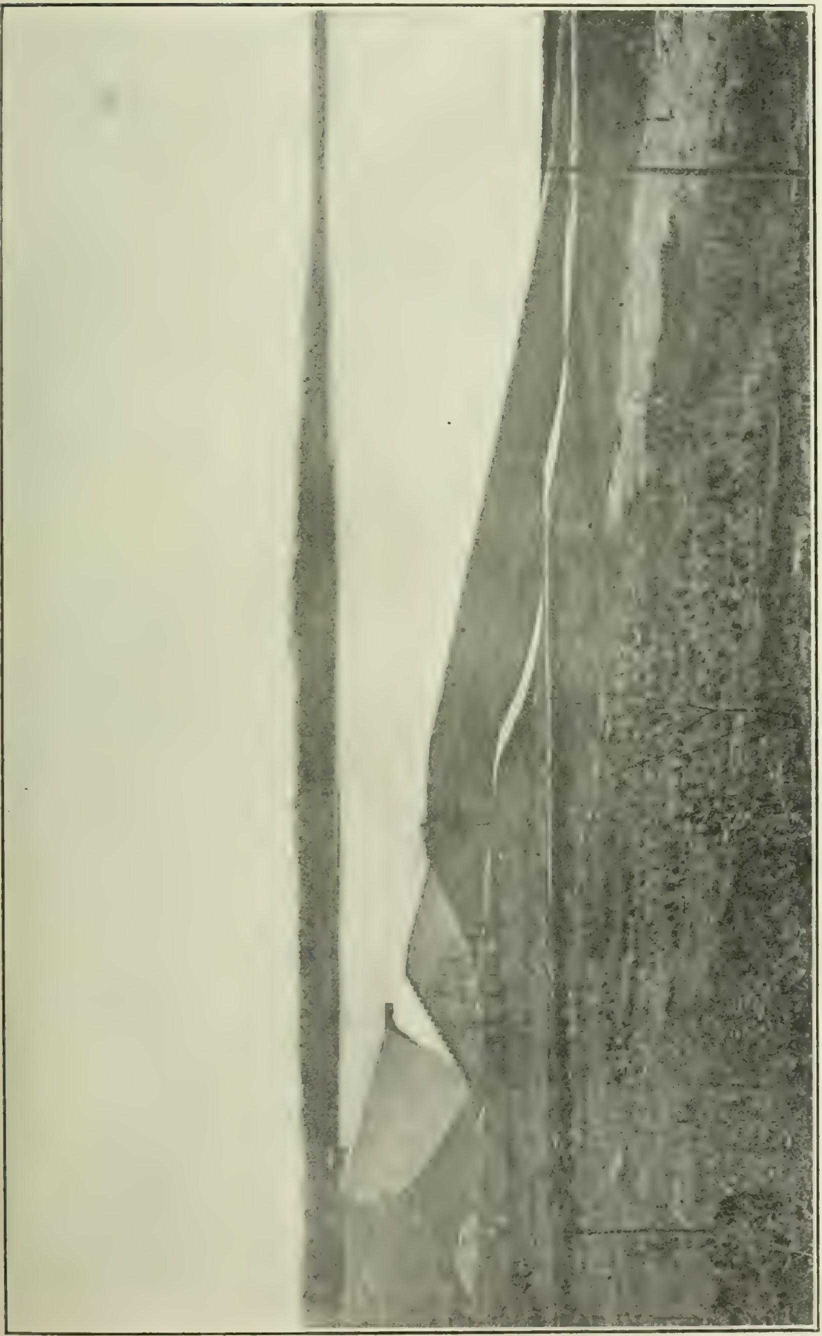
BY J. L. LEAL, A.M., M.D.

Since the latter part of September, 1908, a process of water purification has been in operation at Boonton, N. J., which I believe will be of great interest to scientists and to purveyors and consumers of water. The water treated is the supply of Jersey City, N. J., and is controlled by the Jersey City Water Supply Company. The process employed has been called a "sterilization" process, but is properly one of disinfection. It consists in the addition to the water of so-called "bleach," used in very minute quantities. It is the first time, to my knowledge, that such a process has been applied, as a permanent one, to a water supply. There is one instance on record in which the same process was used, as a temporary expedient, during a typhoid fever epidemic due to infected water supply. This was at Maidstone, England, during the 1897 typhoid epidemic, when a solution of bleaching powder was used by Sims Woodhead for sterilizing the Maidstone water supply. During an outbreak of typhoid fever in Lincoln, England, in 1904–1905, a solution of "chloros" (a commercial preparation of hypochlorite of soda) was used by Drs. Houston and McGowan, to sterilize the water going to the filters, and also to sterilize the reservoirs. In both these instances good results were obtained.

Dr. Rideal has also used solutions of bleach in connection with the Guilford, England, water supply, but only experimentally.

Somewhat similar processes have also been tried, with more or less success, on the waters of the rivers Seine and Vanne in France and at Middlekerke and Ostend in Belgium.

Rather extensive experiments were made with solutions of bleach and soda, in the early nineties, by Mauritz Traube,



BOONTON RESERVOIR

Alois Lode, Sickenberger, Kaufmann, Bassenge, Hunermann, Deiter and Ballner, their object being to obtain practically instantaneous sterilization or disinfection of water for the use of travelers or troops in the field. Their results, although not attaining the end sought, were successful in establishing the efficiency of both calcium and soda chlorides as disinfectants of water.

Electrolytic solutions of sea-water or salt have been used in a number of instances, as at Worthing, England; Nice, France, and at Poplar, England, for general disinfecting purposes, including street watering; for application to sewage effluent at Maidenhead, England; by Rideal, for application to sewage effluent at Guilford, England, and by Woolf for the disinfection of sewage effluent at Brewsters, N. Y., the disinfection of Jerome Park Reservoir of the New York City water supply, and for general disinfection purposes at Havana and Vera Cruz.

Solutions of bleach have been used for the disinfection of sewage or sewage effluents on the river Brent in England; at Hertford, England; on the Hooghly River, India; at the Tittagurh installation near Calcutta, India. and at Guilford, England; by Schultz of Hamburg in connection with the effluents of hospital sewage works; by Phelps at Baltimore, Md., and Red Bank, N. J.; by Pratt and Kimberly at Camp Perry and other points in Ohio, and by others at numerous places, with generally successful results.

No especial discovery, therefere, is claimed in connection with the process in operation at Boonton, N. J.

I do claim, however, that it is the first time that it has ever been used on any such scale, or as a continuous or permanent system of water purification, and I also claim that as a result of the investigations made by us, certain facts in connection with the process have been obtained, which had not been heretofore recognized.

The Jersey City Water Supply is obtained from the Rockaway River, a tributary of the Passaic. The supply is impounded in what is known as the Boonton Reservoir, having a capacity of 8500 million gallons, and is conveyed by a line consisting partly of concrete conduit, partly of tunnel and partly of steel pipe, a distance of 23 miles to Jersey City; the average draft being 40 million gallons daily.

In order to understand the causes which led up to the adoption of this system of purification, it will be necessary to go, very briefly, into history. In the year 1899 the city of Jersey City entered into a contract with a certain contractor for this water supply. Said contractor at once transferred the contract to a corporation which he had organized for the purpose, called the Jersey City Water Supply Company. Work was started by said company, but, becoming financially embarrassed, they were forced to stop. Various attempts were made to finance the project, but all proved failures until in the spring of 1902 the New Jersey General Security Company was induced to assume control of the Jersey City Water Supply Company and to fulfill its contract obligations. The work was at once resumed and pushed vigorously to completion in the latter part of the year 1904.

In the meantime, however, the city had started suit in the Court of Chancery against the company, claiming that the work was not being done according to the specifications and contract. The specifications in said contract with regard to the quality of the water were as follows:

> The water to be furnished must be pure and wholesome for drinking and domestic purposes; and the works shall be so constructed and maintained by the contractor that the water delivered therefrom shall be pure and wholesome and free from pollution deleterious for drinking and domestic purposes.

The opinion of the court, rendered May 1, 1908, was in favor of the company on all the points raised, with but three exceptions, namely: (1) A penalty was imposed for some one hundred and forty odd days' delay in the completion of the works; (2) a deduction of some $16,000 was made on account of the lining of a certain tunnel not being strictly in accordance with the contract, and (3) the court's finding as to the quality of the water was, briefly, as follows:

> (*a*) That during most of the time the water was pure and wholesome, free from pollution deleterious for drinking or other domestic purposes, according to the contract; (*b*) that owing to certain combinations of circumstances, occurring perhaps two or three times a year (meaning times of high water or flood) the water as delivered at Jersey City contained too high a bacterial count and that B. coli were present in too small quantities of water and was therefore of "doubtful" quality; (*c*) that the company was obliged under the contract to deliver a water that was on these few days of

> the year pure and wholesome, free from pollution deleterious for drinking or other domestic purposes: (*d*) The purification of the water could be effected by means of a filter plant. To construct it and to convey the filtered water to Jersey City, at the head contracted for, would involve a great expense. It would have been so important a part of the scheme that had it been contemplated, it would, naturally, have been mentioned in the agreement. The bill does not pray for any deduction grounded upon its absence. It may, therefore, be dismissed from consideration unless the evidence shows that it is indispensably necessary to a complete performance of defendant's contract obligation. I do not think it does.

The court then goes on to suggest, not as its own opinion, but on account of certain evidence given by the city in the case, that the water on these certain days could he made to comply with the contract by the construction of sewers and sewage disposal works for various towns in the watershed.

I was firmly convinced that such a course would not prevent the conditions criticised by the court, but that after the expenditure of the very large sums of money required to perform such work, the company would be left in the same position as indicated by the opinion; believing, as I did, that by far the greater percentage of bacteria and B. coli found at the point of delivery in Jersey City was due more to the washings of soil, roads, streets, manured fields, etc., than from any sewage contamination, it being understood that there are no sewerage systems in any of the towns in the watershed.

I therefore advised strongly that the court be requested to allow the company to suggest to it its own method for the complete fulfillment of the contract requirements. This prayer was made and granted by the court in the decree filed June, 4, 1908, as follows:

> In lieu of and as a substitute for all or any of the sewers and sewage disposal works above referred to in this paragraph, the defendant company may, within ninety days from the date hereof, present other plans or devices for maintaining the purity of the water delivered by the company to the city throughout the year, under present conditions, and estimates of the cost of the works now necessary therefor; and both parties may present evidence touching the efficiency of such plans or devices to produce the necessary results, and the cost thereof; and the defendant company may, pending the taking of testimony, with the leave of the Court, upon notice, present amendments and modifications of such plans and devices.

Upon the rendering of the opinion, May 1, 1908, I began to consider the means necessary to accomplish the objects indicated in said opinion. Under all the circumstances, it seemed to me that the method indicated was one of sterilization or disinfection. I had made rather extensive experiments with electrolytic solutions of salt and also with solutions of bleach, as early as 1897 or 1898, in connection with the proposed purification of another water supply. The results were most favorable from a bacterial standpoint, although the method was not used because it did not fulfil all the requirements of the water under consideration. My first idea therefore was to use an electrolytic solution of salt in connection with the Jersey City supply. I was unable, however, to find a proper cell, and as time pressed, after the rendering of the decree, June 4, 1908, I decided to recommend to the company the use of chloride of lime. Before doing so, however, I was firmly convinced in my own mind of the following facts, as they have since been proved, although at that time there was a good deal of difference of opinion upon some of them, namely:

1. That bleach on being added to water ceases to be bleach, and therefore that criticisms which had been hitherto applied to such addition were without foundation.

2. That on the addition of bleach to water the loosely formed combination forming the bleach splits up into chloride of calcium and hypochlorite of calcium. The chloride of calcium being inert, the hypochlorite acted upon by the carbonic acid in the water, either free or half-bound, splits up into carbonate of calcium and hypochlorous acid. The hypochlorous acid in the presence of oxidizable matter gives off its oxygen; hydrochloric acid being left. The hydrochloric acid then drives off the weaker carbonic acid and unites with the calcium, forming chloride of calcium.

3. That the process was wholly an oxidizing one, the work being done entirely by the oxygen set free from the hypochlorous acid in the presence of oxidizable matter.

We have used, during our investigations, the term "Potential Oxygen" as expressing its factor of power. When set free, it is really nascent or atomic oxygen, and is in its most active state entirely different from the oxygen normally in the water.

4. That no free hypochlorite or hypochlorous acid would be left in the treated water in the presence of oxidizable matter. It is true that at times in the treated water at Jersey City we

have been able to obtain the reaction for so-called available chlorine, according to the method of Wagner as modified by Shultz, there being always oxidizable matter present in such water, and it has been a matter of a good deal of discussion as to the true explanation of this. In my opinion, however, the matter has been definitely settled by the experiments and findings of Prof. Franklin C. Robinson of Bowdoin College, who first found such reaction in untreated Boonton Reservoir water, and afterwards in over seventy-five natural waters. It is but natural, then, to conclude that this test for so-called available chlorine is simply a test for an oxidizing agent present in the water, be that what it may.

5. That any of the atomic oxygen left after the first explosion, by which the more easily oxidizable substances are destroyed, unites with those not so easily oxidizable and more slowly accomplishes the same results.

6. That no free chlorine could possibly exist in the treated water, the existence of free chlorine being impossible in an alkaline solution.

7. That there could be no material change in the quality of the water after treatment, such as would in any way interfere with its use for potable and manufacturing purposes.

8. That it could in no way injuriously affect piping, fixtures, etc.

Justified in my own mind by the above convictions, I therefore made the recommendation above indicated. The recommendation was approved and on June 16, 1908, I engaged the firm of Messrs. Hering and Fuller to design the necessary works, and Mr. George A. Johnson of said firm to operate the same.

I shall not enter into a description of these works, nor of the technical details of the process, as my friend, Mr. Fuller, who follows me, will do both; neither will I go into the details of operation or the results, which will be covered by my friend, Mr. Johnson, who was in immediate charge of the works.

I will, however, briefly sum up such results and their application.

The plant was started September 26, 1908. The results, chemically, have been that the water is practically unchanged in character by treatment, the hardness being very slightly increased from one to two parts per million, the solids slightly increased and the carbonic acid lessened. The differences, however, are only such as would result in samples taken at different periods or through the personal equation of different analysts. Bacterially the results have been most gratifying. For weeks at a time the water taken at a point three-fourths of a mile below the works has been practically sterile, and the count at Jersey City has been from sterile to an average of 20 or 30, with B. coli present in 10 cc. only three times up to April 27, 1909. The bacteria in the raw water have run from 200 or 300 to 20,000, with B. coli frequently present in .1 cc.

The oxygen seems to have a selective effect upon bacteria in general, but especially upon the intestinal group. We have at times, while experimenting, obtained counts of as high as 1000 in treated water with no B. coli present, whereas B. coli were present in one-tenth cc. in the untreated water.

Many experiments have been made by means of putting in the treated water typhoid bacilli, B. coli., etc., with the result of their rapid destruction. Fecal matter and also fecal matter of typhoid patients has been treated by solutions of bleach, resulting in the rapid destruction of all typhoid and colon organisms. The greatest surprise we have experienced, however, has been the small quantity of the chemical necessary to accomplish the required results. I use, as a rule, 0.2 parts per million of so-called available chlorine. There have been two or three occasions when, on account of very high water, I have, in order to be absolutely sure of results, increased the amount to 0.35 parts per million. I am perfectly satisfied that it will never be necessary to increase beyond the latter amount. Of course, we started with much larger amounts, but have gradually reduced them, as we found that we could accomplish the same results.

The cost is almost nominal, being about 14 cents per million gallons of water treated. Mr. Johnson will enter into this feature fully.

Mr. Johnson was able some time in December to discover an electric cell with which we can accomplish most satisfactory results, so that at the present time we have the option of proceeding as we are now doing, or of installing a plant of these cells and using an electrolytic solution of salt. As we have water power, therefore electric current costing us practically nothing, the cost of operation would be a little less than the cost of the bleach process. The efficiency seems to be just the same, as shown by a number of experiments made by Mr. Johnson and myself in which we treated the Jersey City water supply for 49 hours with electrolytic solution of salt, obtaining practically the same results as we had obtained with the bleach process.

This system, however, whether by the use of bleach or an electrolytic solution of salt, is not by any means applicable to all waters. It does not, in most instances, take the place of filtration, except under certain conditions. It answers the purpose better than anything known, from a sanitary standpoint, but it does not remove suspended matter, nor does it remove color except to a very slight degree. It is applicable to waters from large reservoirs where the water has received sufficient sedimentation and bleaching, and to the waters of large lakes if such waters be satisfactory from the æsthetic standpoint.

I believe that one of its most important uses in the future will be in conjunction with filtration. It will certainly effect any bacterial results required, thus making greater rates possible than with ordinary sand filtration and diminishing the cost, and in mechanical filters making less sulphate of alumina necessary and also allowing greater rates. I know of several mechanical filter plants now about to use bleach in connection with their existing systems, and I also know of a plant building in which it is planned so to do. I personally have used it for a period of several weeks in conjunction with a mechanical filtration plant of the highest type, in which, although the bacterial efficiency was satisfactory, yet on account of the large numbers of bacteria in the raw water, the number in the filtered water was anywhere from 300 to 800. By the addition of the bleach in the amount of 0.35 parts per million, I was able to reduce the amount of sulphate of alumina used and secure an effluent containing anywhere from 2 or 3 to 40 bacteria, the numbers averaging the same in the raw water.

This process will also be used in cases where towns or companies are financially unable to build filtration plants, but are forced for sanitary reasons to adopt some means of purification. It will be used also, I believe, in cases of emergency, where water supplies have become infected and where it is impossible to cease using such supplies. In many such ways the practical application of the use of bleach for the disinfection of water supplies seems to me to be a great advance in the science of water purification. It is so cheap, so easy and quick of application, so certain in its results, and so safe, that it seems to me to cover a broader field than does any other system of water purification yet used. It cannot but conduce to the economic and physical benefit of mankind.

Associated with me in this undertaking have been Mr. Rudolph Hering, Mr. George W. Fuller, Mr. George A. Johnson, Mr. E. G. Manahan, of New York; Mr. John H. Cook, Hydraulic Engineer of the Jersey City Water Supply Co., Prof. H. B. Cornwall of Princeton University, Mr. A. W. Cuddeback, of the Jersey City Water Supply Co., Mr. J. W. Ellms, of the Cincinnati Filtration Works, Prof. Leonard P. Kinnicutt of the Worcester Polytechnic Institute, Prof. Wm. P. Mason of the Rensselaer Polytechnic Institute, Dr. George E. McLaughlin of Christ Hospital Laboratory, Jersey City, Prof. W. H. Park of Bellevue and the New York Research Laboratory, Prof. Franklin C. Robinson of Bowdoin College, Prof. Thomas B. Stillman of Stevens Institute, and Prof. F. F. Westbrook, Dean of the University of Minnesota.

Assisting in the work were: Mr. Frank W. Green, Superintendent of Filtration Works of the East Jersey Water Company, Mr. H. C. Stevens, Mr. L. R. Whitcomb and Mr. Guy Britton.

To these gentlemen I wish to express a debt of gratitude for the intense interest in and devotion to the work which they displayed. The services rendered by them could only have been dictated by a scientific interest and confidence in the results hoped for.

DESCRIPTION OF THE PROCESS AND PLANT OF THE JERSEY CITY WATER SUPPLY COMPANY FOR THE STERILIZATION OF THE WATER OF THE BOONTON RESERVOIR.

BY GEORGE W. FULLER

The purpose of this paper is to outline the more important technical details of the process adopted at the Boonton reservoir of the Jersey City Water Supply Company, to destroy objectionable bacteria under the conditions stated by Dr. Leal; and also to describe the plant designed by Hering & Fuller for this sterilizing process and the results of the operation of which since September 26, 1908, will be given in the paper of Mr. Johnson. .

NATURE OF PROCESS

This process is essentially one of oxidation by which the objectionable bacteria in the water under treatment are destroyed. It is also spoken of as a "sterilization process," a name which is quite appropriate from a practical viewpoint, although not absolutely correct theoretically speaking. As a matter of convenience the plant designed for the Jersey City Water Supply Company, to be used at the Boonton reservoir for the purpose above stated, is generally spoken of as a "sterilization plant."

AGENT OR CHEMICAL USED

For the purpose of securing the oxidation and sterilization above mentioned the Boonton reservoir water is treated with a minute dose of bleaching powder of a high degree of purity. This compound, commonly spoken of as hypochlorite of lime, is in reality a mixed salt of calcium containing about equivalent proportions of chloride of calcium and hypochlorite of calcium. This compound is acted upon by the moisture in the atmosphere and hence is transported for the trade in tight metal drums to preserve its initial strength so far as practicable. Ordinarily this compound contains some 35 per cent of available chlorine and some 40 to 44 per cent of lime. The remainder is made up of water, part of which is combined with the chemical and part of it is uncombined water in the form of moisture, together with several impurities coming for the most part from the slaked lime used in preparing this salt.

COMPOSITION OF APPLIED CHEMICAL IN WATER.

When this applied chemical is dissolved in the water it no longer exists as a mixed salt of calcium, but appears in the form of two salts of calcium, namely, calcium chloride and calcium hypochlorite. The former of these salts remains inert and ineffective as applied to natural waters, and it is the second salt (hypochlorite of calcium) which alone serves as an oxidation and sterilization agent.

EFFECT OF CARBONIC ACID UPON HYPOCHLORITE OF CALCIUM

When the active portion of the applied chemical, that is, the hypochlorite of calcium, is added to any ordinary natural water such as that in the Boonton reservoir, the free corbonic acid or half-bound carbonic acid in the water combines with it and there is formed calcium carbonate, and at the same time free oxychloride, known technically as hypochlorous acid, is released in the water. This latter compound is spoken of by chemists as an acid, but it is an extremely inert acid, as is shown by the fact that in the atmosphere the applied chemical is decomposed by the very weak carbonic acid contained in the air and there is set free hypochlorous acid in the manner corresponding to that taking place in the treatment of the reservoir water, as above mentioned. This oxychloride or oxy-acid is so unstable that in its pure state it is said to be unknown.

NATURE OF OXYCHLORIDE OR HYPOCHLOROUS ACID

While oxychloride of hydrogen or hypochlorous acid is an extremely weak acid it is a fact well known to chemists that it is a powerful oxidizing agent. It effects oxidation in the presence of oxidizable substances by virtue of the liberation of nascent oxygen in consequence of its instability as a chemical compound. At this point it may be mentioned that this treatment is in no sense a chlorine treatment such as is sometimes spoken of and largely because of the use of the same commercial product in bleaching operations. In bleaching the commercial product is treated with strong acids which do break up the chemical and release free chlorine. Even free chlorine is not of itself an oxidizing agent, but in the presence of water it combines with hydrogen and thus sets free oxygen in an atomic or nascent state.

The weak carbonic acid, the only free acid in the Boonton reservoir water, or other natural water, is entirely incapable of releasing the free chlorine; but instead there is produced hypochlorous acid, as above stated, and it is this weak and unstable oxy-acid or oxychloride which gives up its oxygen to form a powerful oxidizing agent. Hypochlorous acid is not a poison. The chlorine of this compound combines with the alkalinity of the water, forming calcium chloride.

ATOMIC OR NASCENT OXYGEN

The Boonton reservoir water is ordinarily well supplied with atmospheric oxygen and in fact during the colder portions of the year is doubtless saturated with atmospheric oxygen. It is to be pointed out here that the oxygen resulting from the application of chemical in this process is not ordinary atmospheric oxygen. On the contrary it is in the most active state and in what chemists speak of as a "nascent state" or "atomic state." In this form at the instant of its liberation from the applied chemical it is by no means the inert agent of ordinary atmospheric oxygen, but in a far more active stage and capable of oxidizing substances which are quite unaffected by the oxygen of the atmosphere as ordinarily present, either in the atmosphere or in natural waters.

The expression "potential oxygen" has been used on this work to indicate the strength or quantity of oxygen which could be produced from the applied chemical. It is a much more rational expression than the "available chlorine" of the industrial chemists because as applied to water no chlorine as such becomes available.

SIMILARITY OF RECOMMENDED TREATMENT TO THE SO-CALLED OZONE TREATMENT

The word "ozone" means a modified form of oxygen capable of far more intense oxidation than the ordinary atmospheric oxygen. It is produced by nature under certain atmospheric conditions and by certain processes in the laboratory, and in recent years its production on a large scale through the aid of electricity has constituted one of the most interesting lines of investigation as regards water purification. Difficulties in securing its uniform production in a reliable manner has been and still is a serious draw-back to its use as an oxidizing and sterilization agent in the field of water purification. For that reason another process was recommended in this case for securing the same working agent by other and cheaper means and in such a manner as to put the control of the treatment within the reach of the operators of the plant at all times.

COMPOSITION OF THE BOONTON RESERVOIR WATER WITH REFERENCE TO ITS OXIDIZABILITY

The principal substances or compounds in the water of the Boonton reservoir which are capable of oxidation under favorable conditions are those substances generally spoken of as organic matter. Some of this organic matter is dead, disintegrating and partially dissolved, and some of it is living organic matter comprising the bodies of various small micro-organisms, notably bacteria and certain forms of algæ, diatoms and the like.

There are also some mineral substances or compounds in the reservoir water which are not in an oxidized form, but which can be oxidized under certain conditions. They are present in very minute traces, such, for instance, as nitrogen in the form of nitrites. Another compound which is capable of passing to a more highly oxidized form is that of nitrogen in the form of free ammonia, as spoken of by the analyst, and which exists in water, for the most part, in the form of ammonium carbonate.

While it is true that the substances last mentioned are present in very minute quantities in the reservoir water, it is also true that the dose of applied chemical in this process is also very minute as regards the quantity of "potential oxygen" which it possesses. By potential oxygen is here meant the content of the applied chemical as to the amount of oxygen which it can yield under conditions of complete decomposition under conditions obtained with a natural water such as that in the Boonton reservoir.

In speaking of the oxidizability of certain constituents of the reservoir water on the one hand, and of the potential oxygen applied in the course of the treatment on the other hand, it is to be clearly borne in mind that the quantities are very minute, dealing with fractions of one part of the substance in question in one million parts of water; or, stating it in another form, they are present as very small fractions of one grain to a gallon of water. The significance of these dilutions has a substantial bearing upon the understanding of the practicability and merit of the process in question.

CLASSES OF DEAD ORGANIC MATTER

It is ordinarily said that dead organic matter is present in water either in a dissolved or suspended form. Where particles of disintegrated leaves or twigs are present, and of a size to be visible as suspended matter when viewed by the naked eye, there is no opportunity for mistaking what is meant by that class of suspended organic matter. This class, of course, is more or less present in mixtures with mineral substances resulting from the soil washings of the water shed during rain storms.

As regards organic matter in solution, that is an expression which is not plainly understood by most people. In fact, it is a difficult one to state with precision from the viewpoint of the modern theoretical chemist. For the purposes at hand, however, it may be said that a large proportion of the so-called dissolved organic matter which gives, for instance, the so-called color or vegetable stain to the Boonton water, is not truly in solution in the full chemical sense, but as a matter of fact is in a colloidal state. This colloidal state is an intermediate one between the true solution and the suspension state. It really means that the colloidal particles are in an exceedingly fine state of subdivision and are truly in suspension and not in solution. This is indicated by the inability of large portions of this vegetable stain or color to pass through a dialyzer or parchment, and which is a test of the conditions of substances as to whether they are in a true solution or in a semi-soluble or colloidal state. In the reservoir water organic matter is present in the dissolved, colloidal and suspended forms.

This rough description of organic matters in the reservoir water, such as result for instance from the decomposition of leaves, is of importance in showing the relative amounts of oxidizability of the constituents of the water, because dissolved organic matters, generally speaking, consume potential oxygen more readily than colloidal or suspended organic matter, other things being equal.

CLASSES OF LIVING ORGANIC MATTER

Taking the bacteria as the form of living organic matter of most significance in this problem, it may be stated that bacteria, from the standpoint of readiness of oxidation, may be divided into several classes. The first of these, in which presumably the majority of bacteria are ordinarily present in waters, is the normal or vegetative state in which the cells are found with the tiny bits of protoplasm surrounded by a membrane. As is well known it is in this form that the bacteria are most readily destroyed by oxidation and other forms of sterilization.

A form in which bacteria sometimes occurs and in which it is very difficult to destroy them by oxidation and other means of sterilization, is that known as the "spore" form. When in this condition the normal bacterial cell has practically given place to a small kernel or substance much smaller than the normal cell and within which kernel the protoplasm or essence of life is contained in a thick membrane or sheath, much thicker than the membrane of the ordinary vegetative bacteria. Indeed this membrane is sufficient to protect it from destruction under a great variety of conditions. In practical sterilization it is found that even boiling temperatures of water destroy some of these "spore" forms of bacteria with great difficulty.

Fortunately in the problem at hand the importance of this bacterial condition is comparatively slight and almost negligible for the reason that the specific germs of intestinal diseases, such as typhoid fever, Asiatic cholera, etc., do not form spores and the same is true of B. coli and the majority of the bacteria which dominate the intestinal tract of man and domestic animals.

To obtain a clearer conception of the conditions which actually obtain in a natural water such as that of the Boonton reservoir, especially from the standpoint of destroying all bacteria, it is also to be pointed out that the vegetative bacteria, or the normal bacterial cells, may to a *slight* extent be present in water in the interior of tiny masses of suspended matter, the surfaces of which particles may become sterilized without necessarily having the active oxidizing and sterilizing agent penetrate fully within such suspended particles.

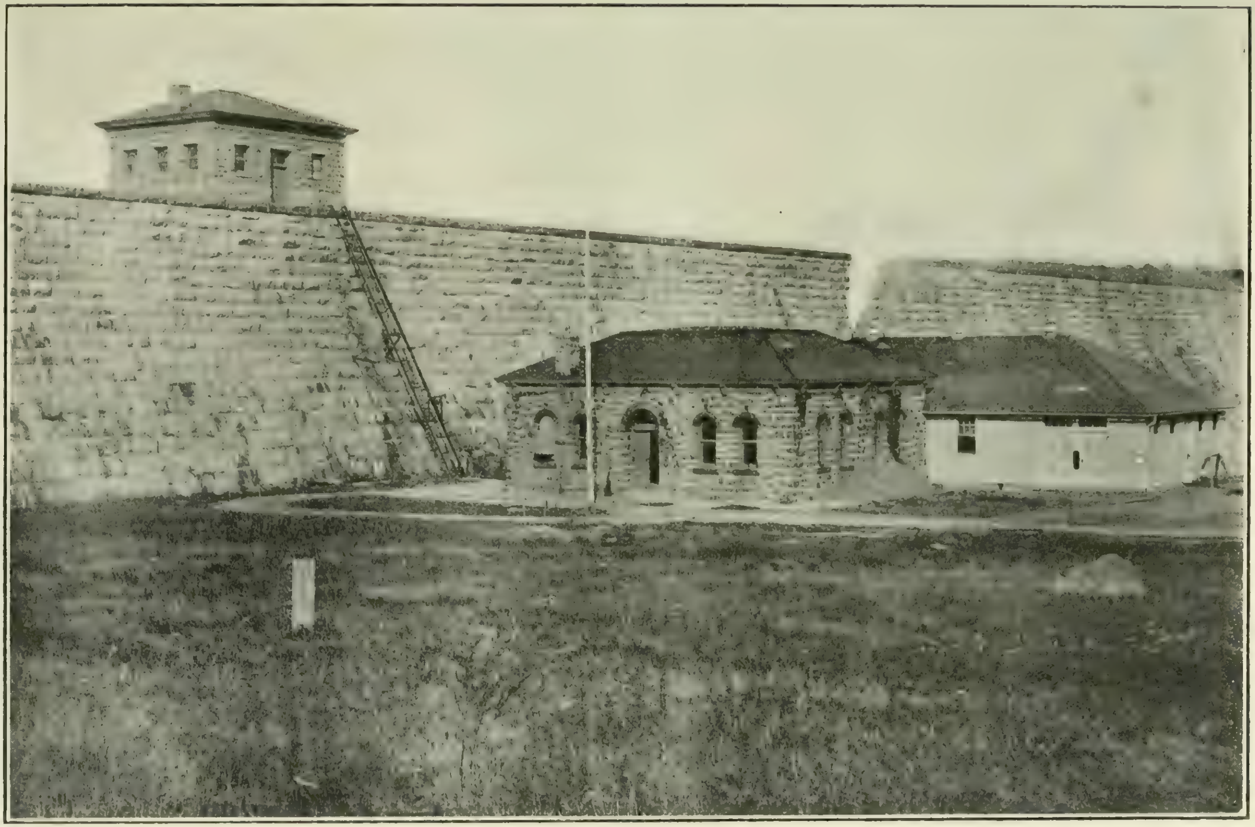
Bacteria in spore form or contained within particles of suspended matter are not killed *entirely* in this process. In making the above statements, it is not to be inferred that the recommended process suffers in efficiency as to destruction of objectionable vegetative bacteria. On the contrary it confirms the reliability of its normal action and furthermore explains the few residual bacteria which are in the water treated by the process just as they are in the effluents of filters.

LOCATION OF PLANT

This plant was built at the large impounding reservoir on the Rockaway River, a tributary of the Passaic, at Boonton, N. J., about 25 miles west of New York City. It is located below the main Boontón dam immediately adjoining the so-called lower gate house, the western end of which is about 30 ft. east of the down-stream face of the dam, measured at ground level. This gate house is located towards the southern end of the dam, the spillway of which is at the northern end. From the upper gate house, built within the dam, to this lower gate house in question there are four 48-in. steel pipe lines conveying water in desired quantities to the gate house which is located at the head of the concrete aqueduct leading towards Jersey City.

The elevation of the spillway of the dam is approximately 305 and the center line of these 48-in. pipes is at elevation 257.25.

The sterilization and oxidation plant was designed to permit the commercial product known as "high grade bleaching powder" or hypochlorite of lime to be dissolved in a convenient manner in tanks located adjoining the lower gate house, whence the solution is pumped with suitable devices into grids of perfo-



BOONTON DAM, UPPER AND LOWER GATE HOUSES AND STERILIZATION PLANT rated pipe placed in the mouth of the several 48-in. pipe lines conveying water from the reservoir to the head of the Jersey City aqueduct.

GENERAL ARRANGEMENTS AND DIMENSIONS OF THE STERILIZATION PLANT

Before taking up the individual details of the works as built, it will be convenient to state in outline the different parts of which the plant consists, as follows:

(*a*) A store-room with a floor area of about 20 by 33 ft.; a main operating room about 30 by 33 ft.; an engine room about 8 by 16 ft.; and a boiler room about 10 by 33 ft.

(*b*) Three dissolving tanks, each 6 ft. in diameter and about 3 ft. deep and placed within the respective solution or mixing tanks, all of which are built of concrete.

(*c*) Three solution tanks, each of a capacity of 1400 cu. ft.

(*d*) Water supply, comprising two 3-in. pipe lines connecting with the 48-in. lines coming from the reservoir, with water under a static pressure of about 15 lb.

(*e*) Stirring devices, consisting of revolving rakes in the dissolving tanks for getting the chemical into solution and also in the solution tanks for keeping the solution mixed so as to be of a uniform strength.

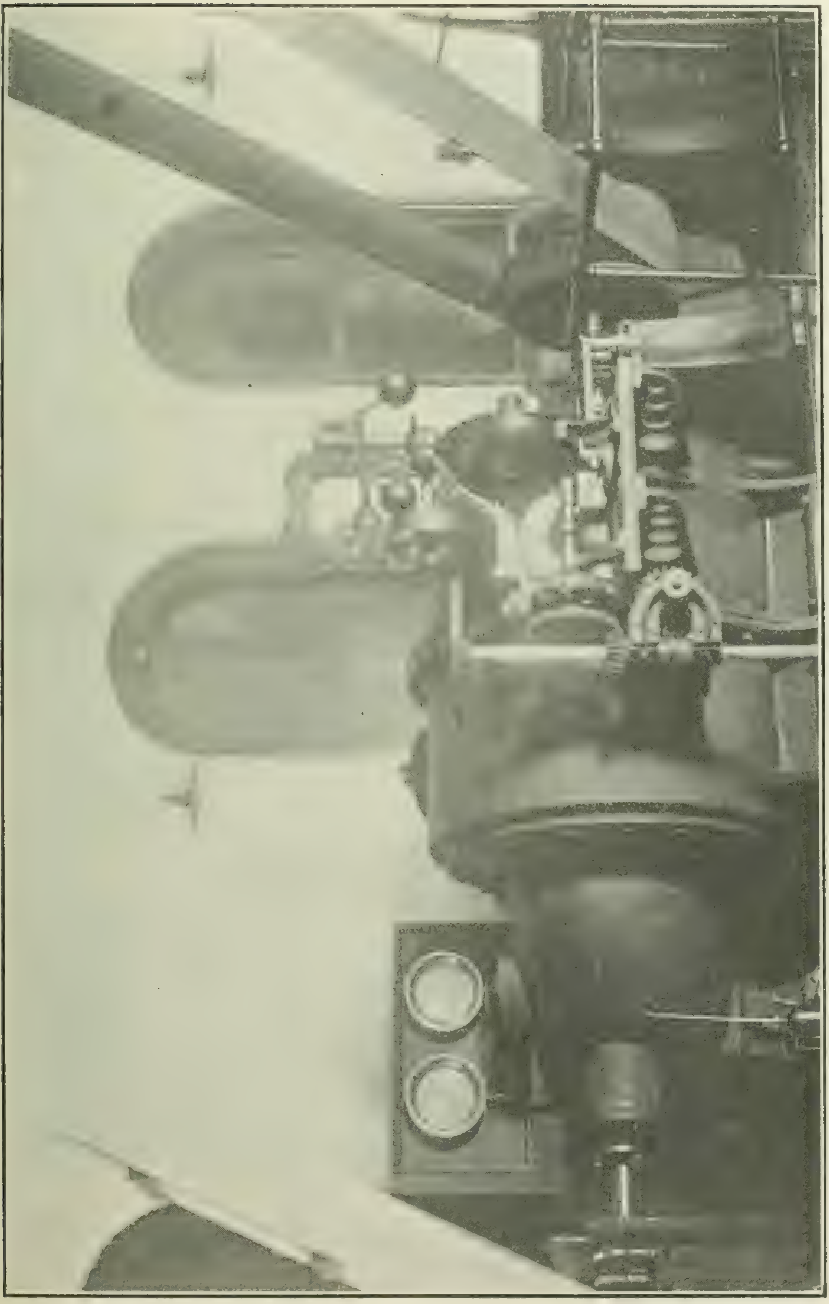
(*f*) Depth recorders by which a continuous automatic record is secured of the level of the liquid in each of the solution tanks.

(*g*) Pumping devices, consisting of two belt-driven 2-in. turbine pumps for delivering the chemical solution from the solution tanks to the orifice tanks.

(*h*) Power equipment, comprising two small boilers and two small engines for driving the shafting to which are belted the pumps and stirring devices, and which temporary steam plant was later replaced by water wheels driven by the water going to Jersey City.

(*i*) Two orifice tanks into which the chemical solution is pumped so as to maintain a fixed depth or head of solution above an orifice, the opening of which is to be adjusted to give the required volume of solution to give the prescribed dose.

(*j*) An alarm system by which a gong is rung with the aid of floats in the orifice tanks to call the immediate attention of the



WATER WHEEL

operators to any lowering of the solution level in the orifice tanks and thus guard against an underdose of solution.

(*k*) A set of perforated pipes or grids placed in the mouth of each of the 48-in. pipe lines coming from the reservoir to the lower gate house and through which grids the chemical solution is to be applied to each of the main pipe lines in service.

(*l*) A general system of pipes and drains for getting the water to the dissolving and solution tanks, connections from these various tanks through the pumps to the orifice tanks, and from the orifice tanks to the point of application through the grids just mentioned.

(*m*) A small laboratory is provided whereby the operators may make suitable tests to regulate properly the prescribed dose of chemical.

(*n*) Miscellaneous appurtenances, such as arrangements for heating, lighting etc.

All of the additional works built outside of the gate house, including the various tanks, pipes, pumps, etc., are included within and beneath a one-story wooden building approximately 33 by 67 ft. in size. This superstructure covers a concrete floor built around and above the various main tanks between which is a pipe gallery. The floor of the boiler, engine and store rooms rest upon an earth fill.

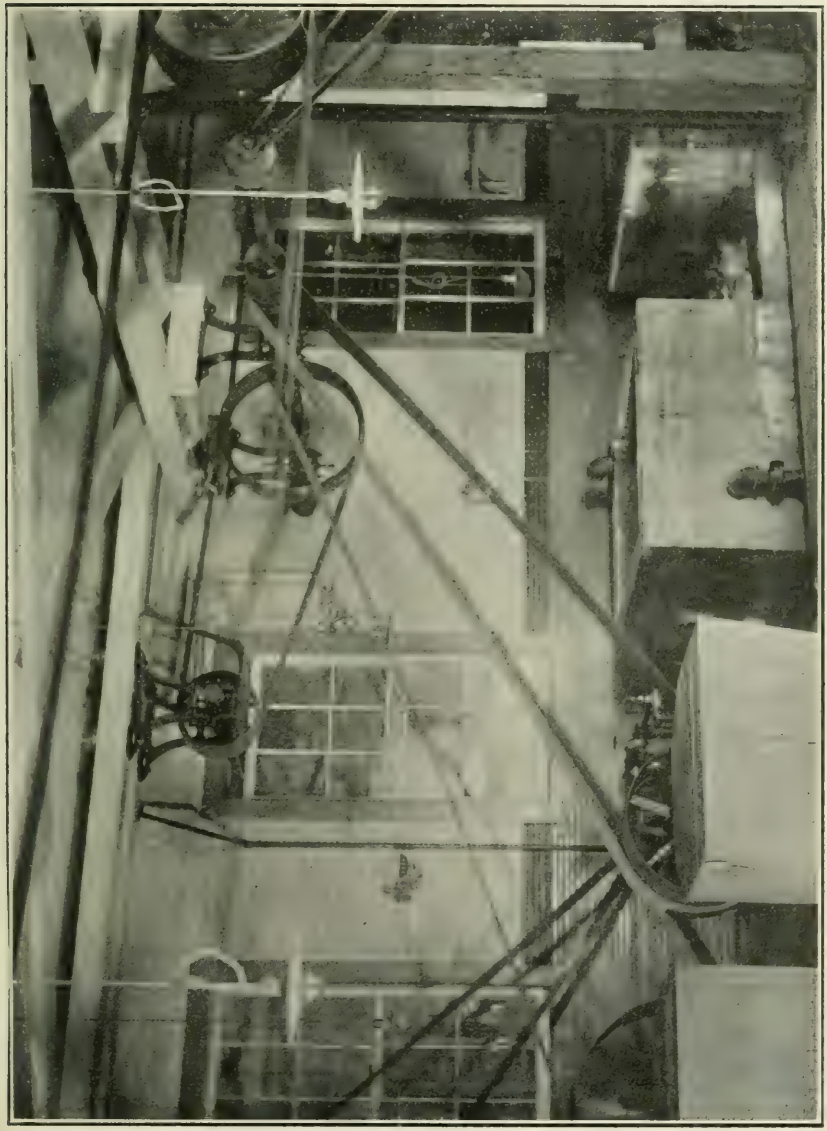
From the figures and plans will be noted the more essential details of each of the above-mentioned parts of the plant, but the more important of these details, such as to allow a good understanding to be obtained as to the nature of the plant, are taken up seriatim, as follows:

CAPACITY OF STOREROOM

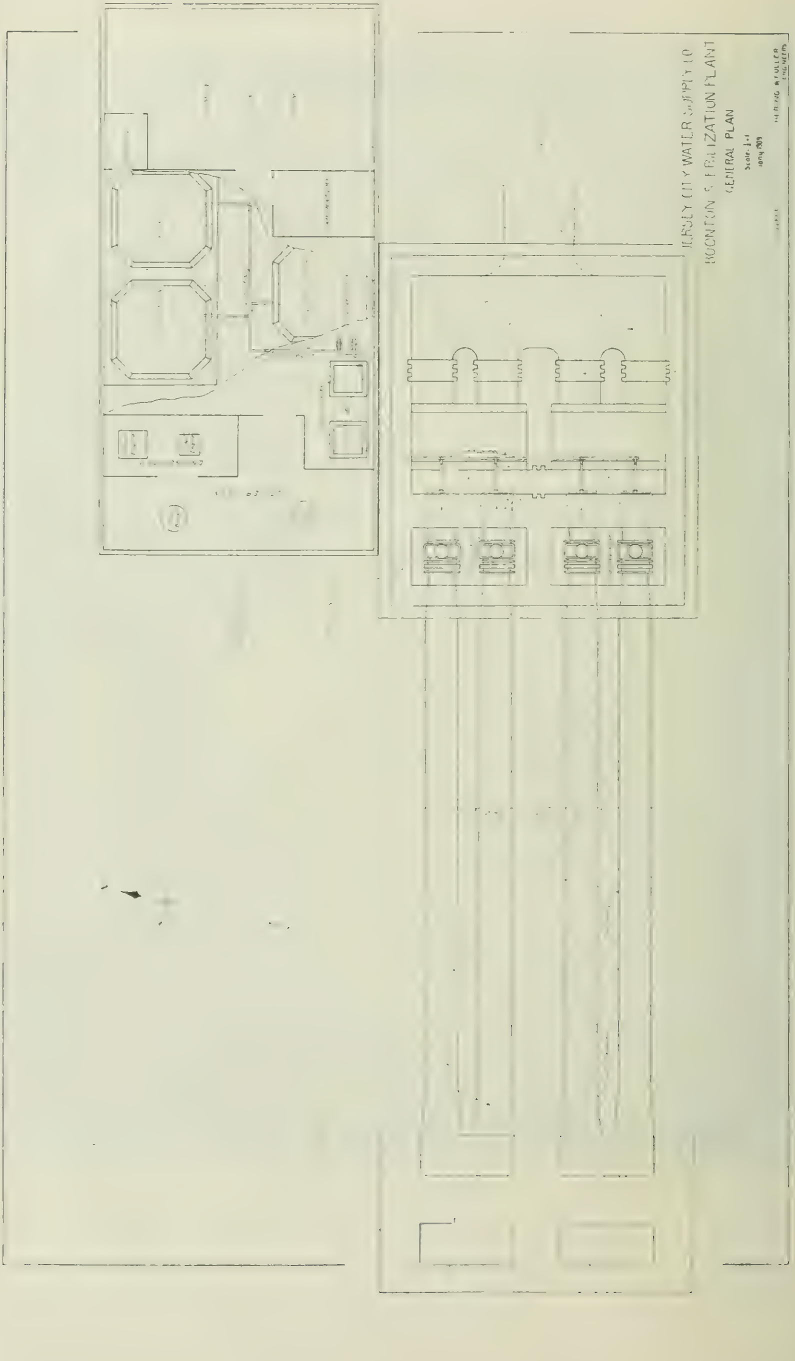
The store room has a capacity of three carloads of bleaching powder, corresponding to 120 drums, or approximately 90,000 pounds. This quantity is more than ample to tide over any interruptions in the delivery of this product, as it would provide for over a year's continuous operation with the present volume of water (40 million gallons daily), according to the present dose applied.

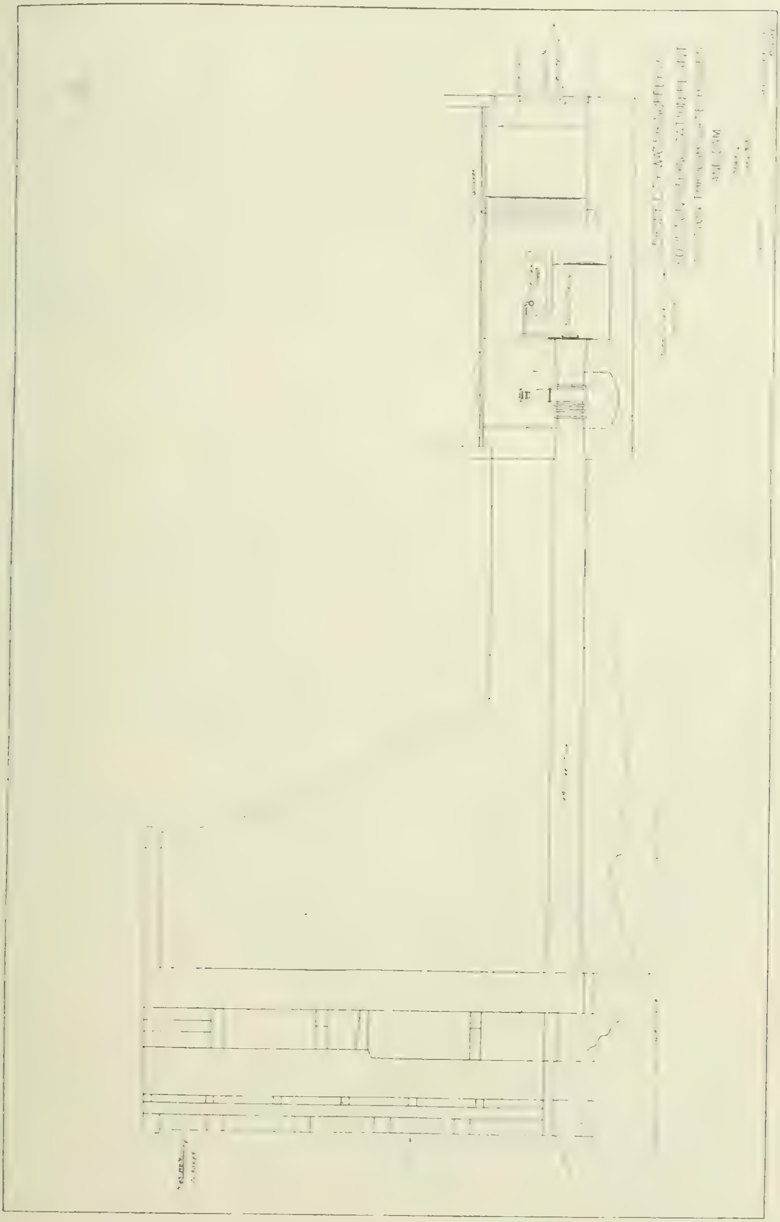
DISSOLVING TANKS

The dissolving tanks, 6 ft. in diameter and 3.5 ft. in gross depth, are built of reinforced concrete with their tops forming a



ORIFICE TANKS


JERSEY CITY WATER SUPPLY CO
BOONTON STERILIZATION PLANT
GENERAL PLAN
Jany 1909
HERING & FULLER ENGINEERS



portion of the floor of the main operating room of the building housing this plant. They are located within the respective solution tanks. Over a portion of the top of the dissolving tanks is a grating made of 2-in. by $\frac{3}{8}$-in. steel bars, spaced on 3-in. centers, through which the dry chemical is dumped.

A 2-in. supply pipe enters the dissolving tanks near the flow line which is 2.5 ft. above the bottom. The center of the 6-in. overflow pipe taking the bleach and water into the solution tank is 18 in. above the bottom. At the bottom is a 4-in. blow-off pipe by which sludge or accumulated solid matter may be removed from these tanks after the soluble matters have been extracted so far as practicable.

SOLUTION AND MIXING TANKS

These are the large tanks into which the solution of chemical is discharged from the dissolving tanks, for purposes of more complete solution as well as complete and uniform mixing with the aid of stirrers. These tanks, of which there are three, are each 11 ft. 3 in. deep, 11 ft. wide at the bottom and 12 ft. 4 in. wide at the top.

They are covered with a concrete deck which serves as a floor of a part of the main room, and in this floor over each tank is a manhole, as shown.

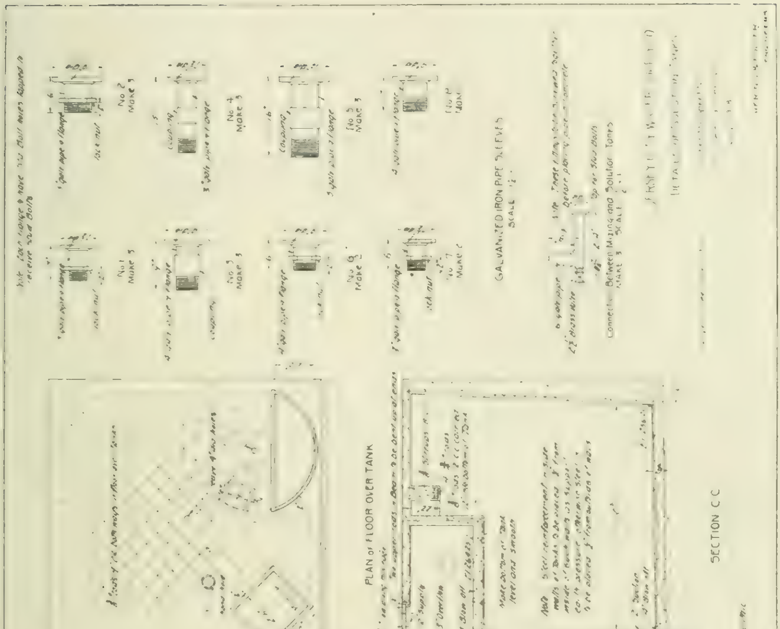
The bottom of these tanks slope to a sump and a 4-in. blow-off pipe from th lowest point provides drainage into a 32-in. steel overflow pipe extending from the adjoining gate house to the stream bed of the Rockaway River below.

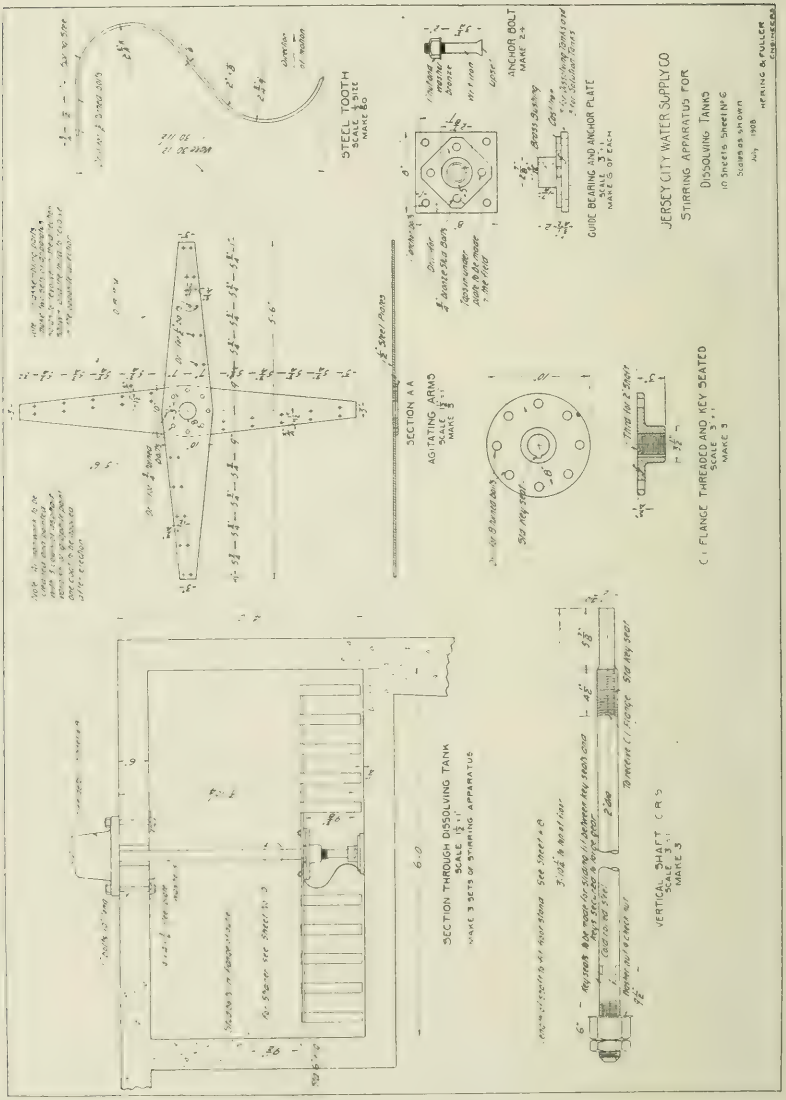
A 2-in. suction pipe leads from just above the bottom of these tanks to the turbine solution pumps.

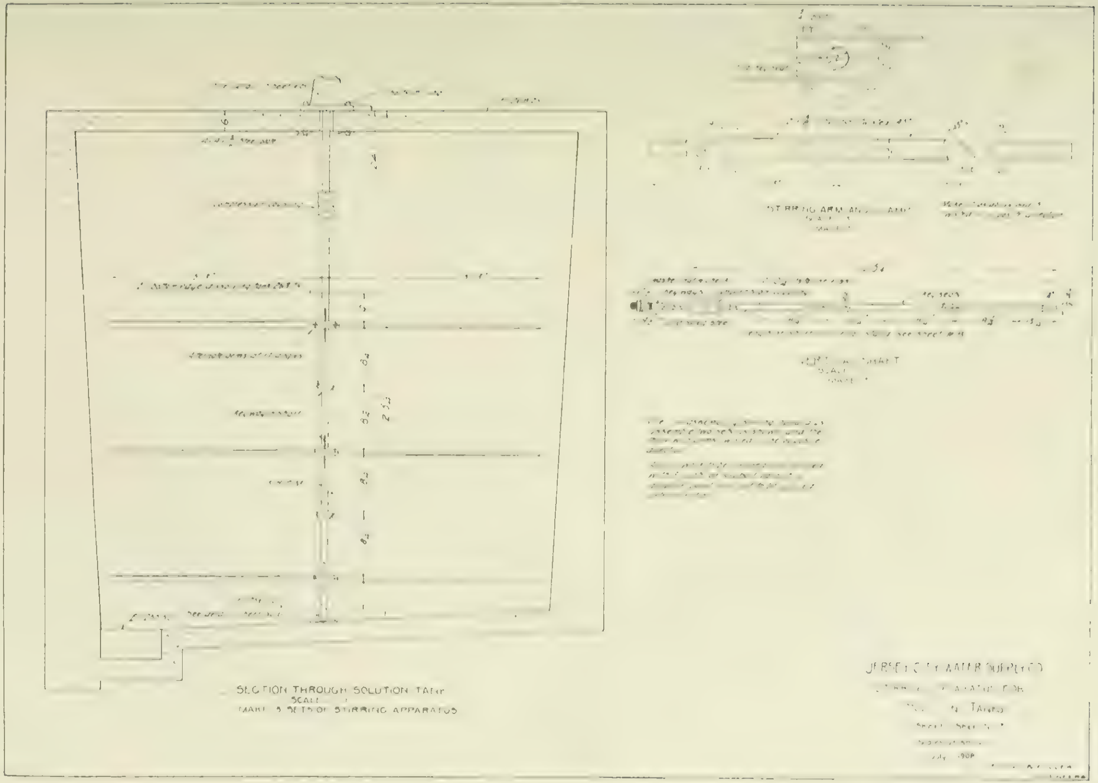
STIRRING DEVICES

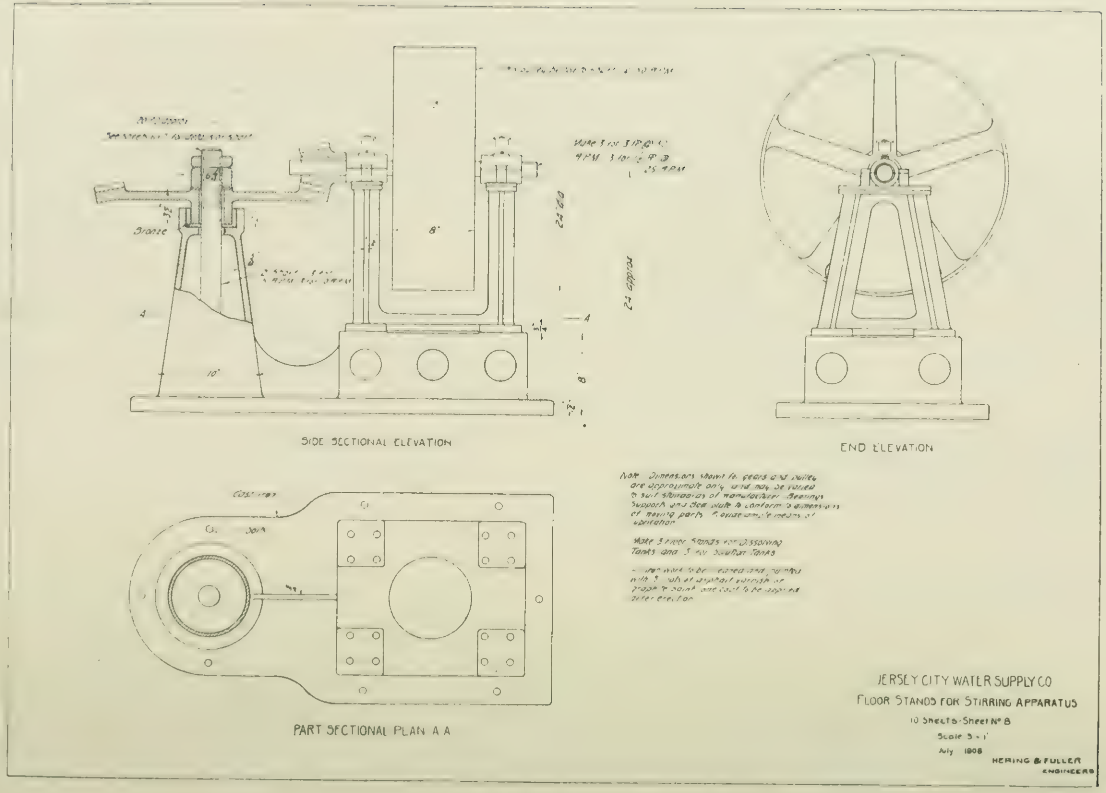
Belt-driven rakes with suitable teeth attached thereto revolve in the dissolving tanks and revolving paddles similarly operated in the solution tanks facilitate solution of the chemical and the maintaining of a solution of uniform strength.

Wooden covers protect the floor stands for these devices from rust so far as practicable.


SECTIONAL PLAN A A
PLAN OF FLOOR OVER TANK
SEC D D
SECTION B B
SECTION C C
SCALE
GALVANIZED IRON PIPE SLEEVES
SCALE
No 1 Make 3
No 2 Make 3
No 3 Make 3
No 4 Make 3
No 5 Make 3
Connections Between Mixing and Solution Tanks


STEEL TOOTH
SCALE ½ SIZE
MAKE 60
SECTION A A
AGITATING ARMS
SCALE 1½":1'
MAKE 3
½" Steel Plate
ANCHOR BOLT
MAKE 24
GUIDE BEARING AND ANCHOR PLATE
SCALE 3":1'
MAKE 6 OF EACH
Brass Bushing
Casting
C I FLANGE THREADED AND KEY SEATED
SCALE 3":1'
MAKE 3
Std Key Seat
SECTION THROUGH DISSOLVING TANK
SCALE 1½":1'
MAKE 3 SETS OF STIRRING APPARATUS
VERTICAL SHAFT C R S
SCALE 3":1'
MAKE 3
Cold rolled Steel
To receive C I Flange Std Key Seat
JERSEY CITY WATER SUPPLY CO
STIRRING APPARATUS FOR
DISSOLVING TANKS
10 Sheets Sheet No 6
Scales as shown
July 1908
HERING & FULLER
ENGINEERS


STIRRING ARM AND
SHAFT
SCALE
SECTION THROUGH SOLUTION TANK
SCALE
MAKE 3 SETS OF STIRRING APPARATUS
JERSEY CITY WATER SUPPLY CO
TANKS
JULY 1908

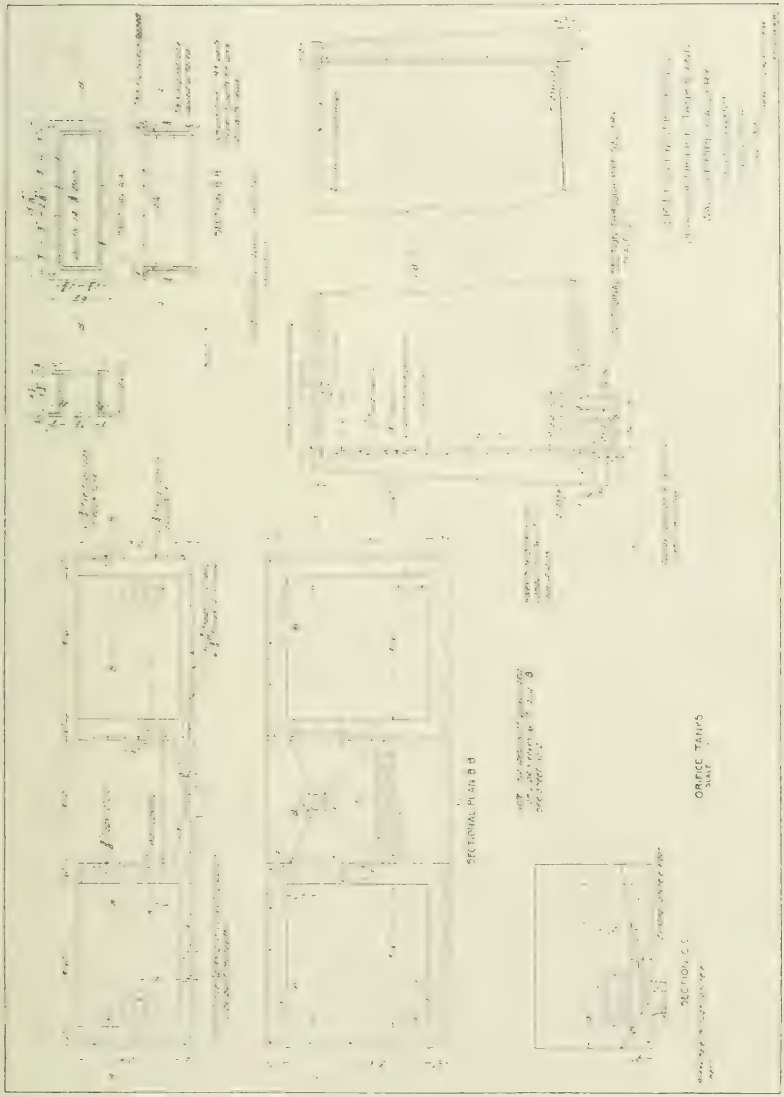


Note Dimensions shown for gears and pulley are approximate only and may be varied to suit standards of manufacturer. Bearings Supports and bed plate to conform to dimensions of moving parts. Provide ample means of lubrication

Make 3 Floor Stands for Dissolving Tanks and 3 for Solution Tanks

All iron work to be cleaned and painted with 3 coats of asphalt varnish or graphite paint one coat to be applied after erection

JERSEY CITY WATER SUPPLY CO
FLOOR STANDS FOR STIRRING APPARATUS
10 Sheets-Sheet No 8
Scale 3 = 1'
July 1908
HERING & FULLER
ENGINEERS


SECTIONAL PLAN B B
SECTION C C
ORIFICE TANKS
SCALE

DEPTH RECORDERS

In each of the three solution tanks are float pipes in which copper floats are placed to actuate a self-recording depth recorder of the standard type. The dials are 12 in. in diameter, which is the size of the chart upon which is recorded continuously the depth of solution in tanks. Glass sight tubes are also attached to the sides of the solution tanks so that by entering the pipe gallery the level of the solution in each tank may be noted by the level in the glass tube.

PUMPS

The belt-driven turbine pumps have 2-in. connections and have a nominal capacity of 25 gallons per minute. They are built of special bronze. One pump is to be used at a time, the other being in reserve.

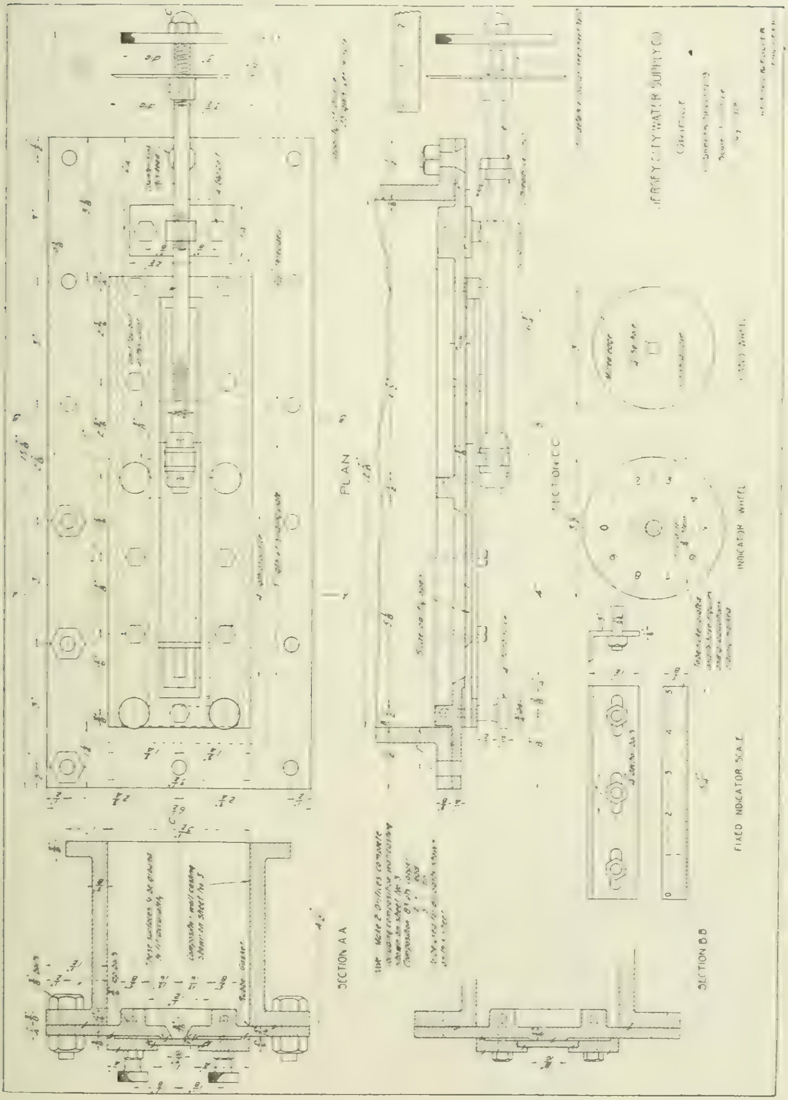
POWER EQUIPMENT

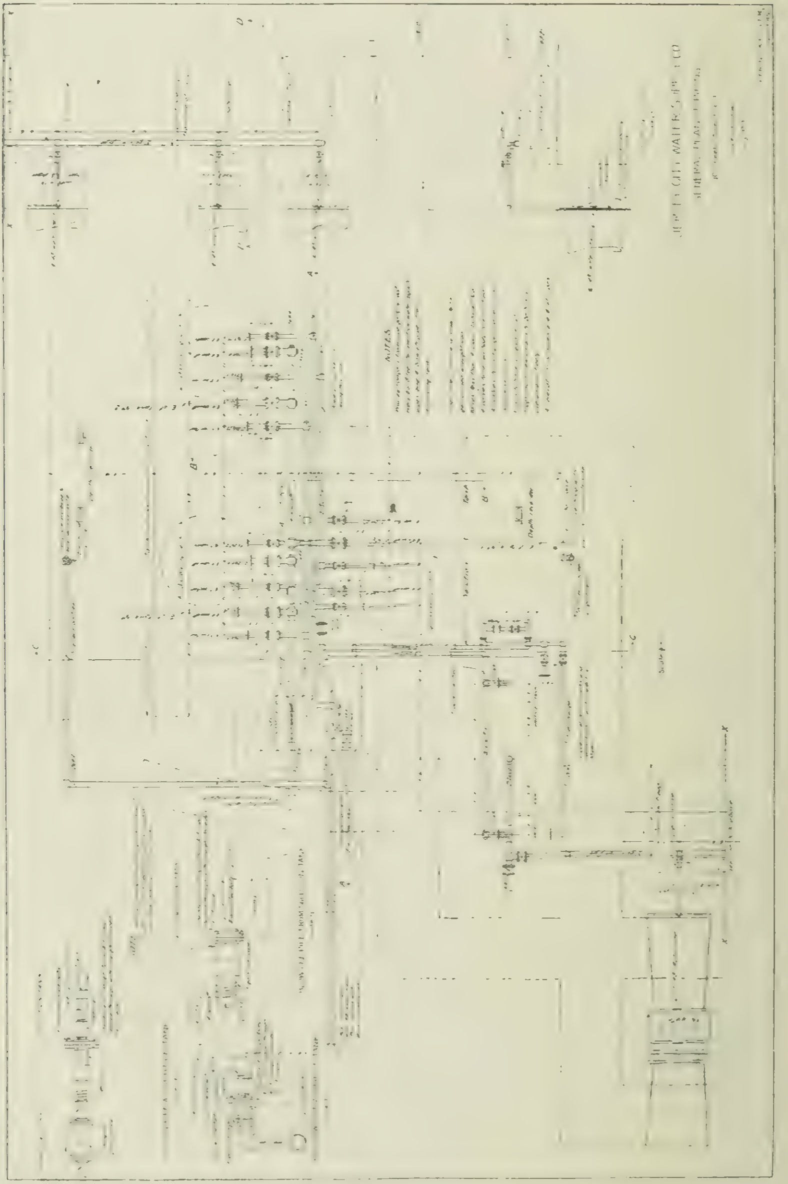
Water coming from the reservoir to the lower gate house on its way to Jersey City drives a 30-h.p. horizontal turbine wheel to develop power needed for pumping and stirring the solutions. Temporarily two vertical boilers of 12 and 15 h.p. and two small engines of 10 and 20 h.p. were used.

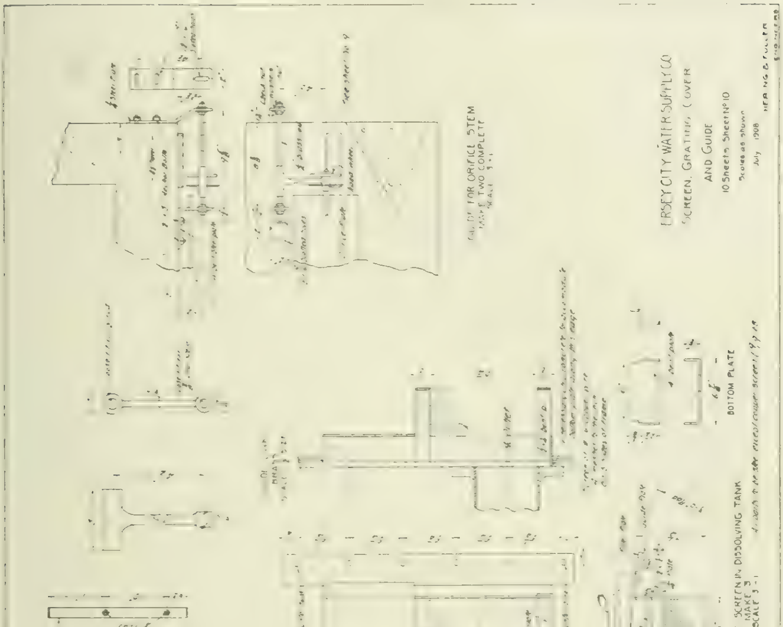
ORIFICE TANKS AND APPURTENANCES

There are two concrete orifice tanks, 3 ft. 6 in. square in plan, and 2 ft. 6 in. deep. The delivery pipe from the pump discharges into either one of these orifice tanks as desired. An excess of solution is always pumped to them, which excess flows back to the solution tank through a 3-in. overflow pipe.

Each tank is provided with an outlet in the shape of an adjustable orifice which is made of a special composition of copper, lead and tin and is arranged so that with the aid of a fine micrometer screw a cover is moved backwards and forwards over a slot, thus permitting the use of an area of orifice found to give the desired volume of solution under a constant head. As already explained the excess volume of solution is taken care of by means of an overflow pipe, thus preventing an excessive head upon the orifice; and any deficiencies in head or depth


PLAN
SECTION A A
SECTION B B
SECTION C C
INDICATOR WHEEL
FIXED INDICATOR SCALE
JERSEY CITY WATER SUPPLY CO
0
1
2
3
4
5




JERSEY CITY WATER SUPPLY CO
SCREEN, GRATING, COVER
AND GUIDE
10 Sheets Sheet No 10
Scales as shown
July 1908
HERING & FULLER
ENGINEERS
GUIDE FOR ORIFICE STEM
MAKE TWO COMPLETE
SCALE 3-1
BOTTOM PLATE
REMOVABLE SCREEN IN DISSOLVING TANK
MAKE 3
SCALE 3-1
GRATING FOR SOLUTION TANKS
MAKE 3
GUARD RAIL AND COVER FOR SOLUTION TANKS
MAKE 3

of liquid over the orifice are indicated almost instantly by a copper float adjusted so as to ring an alarm gong.

Only one device is used at a time, so that as in all other features, the plant is built in duplicate.

PIPING FOR APPLICATION OF SOLUTION TO RAW WATER

The prescribed volume of solution of known strength flows by gravity from the orifice tanks through a 3-in. galvanized iron pipe line into the screen chamber located beneath the floor of the lower gate house. This main pipe branches into 4 lines, each 1.5 in. in diameter and extending to a grid fastened over the mouth of each of the four 48-in. mains coming from the reservoir. The grids are made up of 1-in. pipe drilled with twelve $\frac{1}{4}$-in.openings pointed downward. The grids are fastened in place by $\frac{3}{4}$-in. wrought iron bars bolted to the masonry.

The solution and the water treated are well mixed before entering the concrete aqueduct.

DESCRIPTION OF METHODS OF OPERATION OF THE STERILIZATION PLANT OF THE JERSEY CITY WATER SUPPLY COMPANY AT BOONTON, N. J., AND DISCUSSION OF RESULTS OF ANALYSES OF RAW AND TREATED WATER, WITH NOTES ON THE COST OF THE TREATMENT.

BY GEORGE A. JOHNSON

The purpose of this paper is to describe the methods of operation followed during the first three months' operation of the sterilization plant of the Jersey City Water Supply Company at Boonton, N. J. The historical phases of the subject and a description of the process and the plant at Boonton have been given in the papers of Dr. Leal and Mr. Fuller. In this paper, therefore, only the methods of operation will be described, together with a discussion of the results of analysis of the raw reservoir water and the treated water made in the laboratory of the water company at Boonton and in the laboratories of Dr. George E. McLaughlin at Jersey City and Dr. Wm. H. Park in New York City.

Force Employed.—From September 26 to December 31, 1908, the operation of the sterilization plant at Boonton was under the direct charge of the writer. During that period Messrs. H. C. Stevens and Guy Britton were engineering assistants dividing the duties of the 24 hours of each day, and Mr. L. R. Whitcomb was analyst.

The duties of the engineering assistants were to superintend the preparation of chemical solutions and the application thereof to the water; to prepare accurate records of the rates of application of the sterilizing agent to the water; to collect and test at frequent intervals samples of the chemical solutions in order to ascertain the variation in strength of the same; and to prepare daily reports showing all necessary details of operation. Mr. Whitcomb's duties were to collect and analyze at least once a day samples of the raw reservoir water and of the water after treatment at a point on the aqueduct about one mile below the point of application of the sterilizing agent; and, also, to carry on incidental studies to show the effect of the treatment on particular forms of bacterial life.

CALIBRATION OF TANKS AND ORIFICES

In the beginning each of the tanks in which the chemical solutions were mixed and stored was carefully calibrated and tables prepared showing the content of each tank at different depths. The orifices whereby the flow of solution was regulated were also carefully calibrated and tables prepared showing the discharge through each orifice under a constant head with the orifice opened to a varying degree. With a knowledge of the amount of water which was being delivered into the aqueduct, it was possible by means of these tables to adjust at the orifice the dose of chemical solution with a great degree of accuracy in a moment's time.

PREPARATION OF SOLUTIONS

The bleaching powder was received at the plant in sheet-iron drums holding about 750 pounds, net. This powder was of a high degree of purity as ascertained by frequent analyses of it during the period of operation mentioned. Ordinarily the powder ran about 35 per cent in "available chlorine," equivalent to 7.9 per cent available oxygen. For the majority of the time solutions of 1 per cent strength were used. For a part of the time, as is the case now, ½ per cent solutions were used. By a ½ per cent solution is meant the addition of 5 pounds of dry bleaching powder to each 1000 pounds of water.

In making up a solution the amount of old solution remaining in the tank was first ascertained from the depth recorder and then it was decided to what height the tank was to be filled. By referring to the proper table showing the capacity of the tank between these two gage readings it was then possible to figure the amount of dry bleaching powder necessary to add to make up a solution of the desired strength. This amount of dry powder was then dumped into the dissolving compartment of the mixing tank, raw water turned on, and the agitators started. The solution rising in the dissolving compartment overflowed into the main solution tank, which was filled to the required height through this overflow.

APPLICATION OF SOLUTION

When it was desired to throw a tank into use the proper valves were opened, connecting the suction in this tank with the chemical feed pumps. The solution was tested by the Penot method for its strength in available oxygen by the so-called "available chlorine" method and the orifice on the orifice tank adjusted to give the required dose.

The chemical feed pumps were always operated so as to pump a quantity slightly in excess of that discharging through the orifice, and this excess escaped from the tank through an overflow pipe leading back into the main solution tank. In this manner it was possible to maintain at all times a constant head over the orifice and if, for any reason, the feed pumps stopped, the level of the solution in the orifice tank immediately began to fall, causing an alarm to be rung notifying the operator of the fact. Very little trouble was experienced from clogging at the orifice, and the variation in rate of application of the chemical solution was, therefore, exceedingly slight, being practically negligible.

AMOUNTS OF CHEMICAL APPLIED

In the beginning, not having a thoroughly definite idea of the smallest quantities which could be used with satisfactory results, the amount of chemical applied was 1.4 parts per million of "available chlorine," corresponding to 0.3 part per million of potential oxygen, or 36 pounds of the dry bleaching powder per million gallons of water treated. Gradually the quantity of applied chemical has been decreased until at the present time about 0.2 part per million of "available chlorine" is being applied. This corresponds to 0.045 part per million of potential oxygen, or 5 pounds per million gallons of the bleaching powder.

There has been no striking evidence that the higher quantities were more efficacious in the destruction of bacterial life in the raw reservoir water than the small quantity last mentioned.

The composition and temperature of the raw water apparently affected not at all the rapidity and completeness of the sterilizing action.

A long series of analyses were made with a view to establishing if possible a relationship between the amount of carbonaceous organic matter in the raw water and the amount of sterilizing agent necessary to effect the desired degree of sterilization. The quantities of the sterilizing agent used were so small, however, that there was found to be no such relationship existing. In other places, where the amount of organic matter is much higher than in the raw Boonton water, it is possible that such a relationship may be found to exist.

RESULTS OBTAINED

In the following table are given records showing the amount of water treated each day, the amount of chemical agent applied expressed in parts per million of potential oxygen, the results of bacterial examinations to show numbers of bacteria in the raw and treated water, and of tests for B. coli communis carried on at Boonton and in the laboratories of Drs. Park and McLaughlin.

If there is an apparent disparity in the results of analyses of the treated water at the Romine gate house and at the point of delivery in Jersey City, 23 miles below, and if the numbers of bacteria at the latter point were higher than those at the Romine gate house, as they sometimes were, it shows either that bacteria were still being washed from the old deposits in the conduit, or that there was a slight multiplication among the harmless, forms of bacteria which successfully resisted the treatment. The completeness of the sterilizing action, so far as the destruction of objectionable forms is concerned, is apparent from the results presented. From October 10 to December 31, inclusive, the total number of bacteria in the treated water at the point of delivery in Jersey City averaged 15 per cubic centimeter, and only on one occasion out of 455 tests was B. coli positively isolated from the treated water at the point of delivery in Jersey City, namely, on November 1, 1908, when it was isolated by Dr. Park in 5 cc. of treated water collected at the Summit Avenue gate house in Jersey City.

Official Daily Record of the Results of Operation of the Oxidation and Sterilization Plant of the Jersey City Water Supply Company, at Boonton, N. J., for the Destruction of Objectionable Bacteria in the Raw Water Supply of Jersey City, N. J.

			BACTERIA PER CUBIC CENTIMETER			TESTS FOR B. COLI COMMUNIS.								
Day of the Month.	Total quantity of water treated in million gallons.	Quantity of applied oxidizing agent expressed in parts per million in terms of potential oxygen.	Raw reservoir water at lower Gate House.	TREATED WATER AT:		Raw reservoir water at Lower Gate House.	TREATED WATER AT:							
				Romine Gate House.	Summit Avenue Gate House. Dr. McLaughlin.		Romine Gate House.				Summit Ave. Gate House. By Dr. McLaughlin			
						1.0 cc	1.0 cc	1.0 cc	5.0 cc	5.0 cc	1.0 cc	1.0 cc	5.0 cc	5.0 cc
1	40.0	0.097	....	....	....	–	–	–	–	–	–	–	–	–
2	40.0	0.095	....	....	....	–	–	–	–	–	–	–	–	–
3	40.5	0.088	....	....	....	–	–	–	–	–	–	–	–	–
4	41.0	0.085	....	....	....	–	–	–	–	–	–	–	–	–
5	41.0	0.088	....	....	....	–	–	–	–	–	–	–	–	–
6	41.0	0.108	....	....	....	–	–	–	–	–	–	–	–	–
7	41.0	0.129	....	....	....	–	–	–	–	–	–	–	–	–
8	41.0	0.111	180	1	1,400	+	–	0	–	–	–	0	0	0
9	41.0	0.099	240	2	190	+	–	0	–	–	–	0	0	0
10	41.0	0.104	200	11	70	+	–	?	–	–	–	0	0	0
11	41.0	0.106	160	7	....	+	–	0	–	–	–	0	0	0
12	41.0	0.147	190	3	24	+	–	0	–	–	–	0	0	0
13	41.0	0.162	275	3	28	?	–	?	–	–	–	0	0	0
14	41.0	0.151	220	5	48	?	–	0	–	–	–	0	0	0
15	40.3	0.144	180	6	42	+	–	0	–	–	–	0	0	0
16	40.6	0.151	275	8	30	+	–	0	–	–	–	0	0	0
17	42.4	0.158	220	6	....	+	–	0	–	–	–	0	0	0
18	43.3	0.144	250	4	12	?	–	0	–	–	–	0	0	0
19	42.0	0.156	170	7	12	+	–	0	–	–	–	0	0	0
20	41.3	0.160	190	6	5	+	–	0	–	–	–	0	0	0
21	38.5	0.147	350	10	3	?	–	0	–	–	–	0	0	0
22	39.2	0.147	220	8	4	?	–	0	–	–	–	0	0	0
23	41.0	0.160	275	5	275	?	–	0	–	–	–	0	0	0
24	41.0	0.156	170	4	....	+	–	0	–	–	–	0	0	0
25	41.0	0.151	180	6	8	+	–	?	–	–	–	0	0	0
26	41.0	0.142	375	5	8	?	–	0	–	–	–	0	0	0
27	40.3	0.135	425	4	6	?	–	0	–	–	–	0	0	0
28	40.0	0.142	275	8	9	0	–	0	–	–	–	0	0	0
29	40.0	0.149	600	20	14	+	–	0	–	–	–	0	0	0
30	40.0	0.149	1,400	12	12	+	–	+	–	–	–	0	0	0
31	39.4	0.142	650	12	....	0	–	?	–	–	–	0	0	0

NOVEMBER, 1908

Official Daily Record of the Results of Operation of the Oxidation and Sterilization Plant of the Jersey City Water Supply Co., at Boonton, N. J., for the Destruction of Objectionable Bacteria in the Raw Water Supply of Jersey City, N. J.

Day of the month.	Total quantity of water treated in million gallons.	Quantity of applied oxidizing agent expressed in parts per million in terms of potential oxygen.	BACTERIA PER CUBIC CENTIMETER.				TESTS FOR B. COLI COMMUNIS.												
			Raw reservoir water at Lower Gate House.	TREATED WATER AT:			Raw reservoir water at Lower Gate House.	TREATED WATER AT:											
				Romine Gate House.	Summit Avenue Gate House.			Romine Gate House.				Summit Avenue Gate House.							
					By Dr. McLaughlin	Dr. Park.						Dr. McLaughlin.				Dr. Park.			
							1.0 cc	1.0 cc	1.0 cc	5.0 cc	5.0 cc	1.0 cc	1.0 cc	5.0 cc	5.0 cc	1.0 cc	1.0 cc	5.0 cc	5.0 cc
1	39.6	0.153	325	13	10	12	+	—	0	—	—	—	0	0	0	0	0	0	+
2	40.0	0.158	190	5	13	— —	+	—	0	—	—	—	0	0	0	—	--	—	—
3	40.0	0.151	150	2	8	35	+	—	0	—	—	—	0	0	0	0	0	0	0
4	39.6	0.151	100	3	10	35	+	—	0	—	—	—	0	0	0	0	0	0	0
5	39.0	0.167	190	8	9	40	+	—	0	—	—	—	0	0	0	0	0	?	?
6	39.0	0.165	275	12	5	39	+	—	0	—	—	—	0	0	0	0	0	0	0
7	39.0	0.167	130	5	— —	— —	+	—	0	—	—	—	—	—	—	—	—	—	—
8	39.0	0.162	70	6	10	10	+	—	?	0	0	0	0	0	0	0	0	0	0
9	39.3	0.158	130	5	5	16	+	—	0	—	—	—	0	0	0	0	0	0	0
10	40.0	0.167	90	8	11	10	+	—	?	—	—	—	0	0	0	0	0	0	0
11	39.3	0.155	90	10	2	15	+	—	0	—	—	—	0	0	0	0	0	0	0
12	39.0	0.155	75	10	7	3	+	—	?	—	—	—	0	0	0	0	0	0	0
13	39.0	0.153	200	10	12	3	+	--	0	—	—	—	0	0	0	0	0	0	0
14	39.6	0.153	350	11	— —	— —	+	0	—	—	—	—	—	—	—	—	—	—	—
15	39.4	0.149	210	10	8	6	+	0	0	0	0	—	0	0	0	0	0	0	0
16	39.0	0.138	325	8	3	3	?	0	0	0	0	—	0	0	0	0	0	?	?
17	39.0	0.133	130	5	12	17	?	0	0	0	0	—	0	0	0	0	0	0	0
18	39.4	0.155	200	6	3	2	+	0	0	0	0	—	0	0	0	0	0	0	0
19	40.6	0.167	100	6	2	3	+	0	0	0	0	—	0	0	0	0	0	0	0
20	41.0	0.167	—	2	7	3	?	0	0	0	0	—	0	0	0	0	0	0	0
21	41.0	0.158	85	7	—	— —	?	0	0	0	0	—	—	—	—	—	—	—	—
22	41.0	0.138	150	5	50	1	+	0	0	0	0	0	0	0	0	0	0	0	0
23	41.0	0.149	130	4	12	47	+	0	0	0	0	0	0	0	0	0	0	0	0
24	40.3	0.151	210	5	11	5	?	0	0	0	0	0	0	0	0	0	0	0	0
25	40.0	0.158	30	5	— —	— —	?	0	0	0	0	—	—	—	—	—	—	—	0
26	40.0	0.140	45	4	5	4	?	0	0	0	0	0	0	0	0	0	0	0	0
27	40.0	0.147	700	12	9	3	?	0	0	0	0	0	0	0	0	0	0	0	0
28	40.0	0.151	550	4	—	— —	0	0	0	0	0	—	—	—	—	—	—	—	—
29	40.0	0.158	325	5	11	16	0	0	0	0	0	0	0	0	0	0	0	0	0
30	40.6	0.158	350	2	6	19	0	0	0	0	0	0	0	0	0	0	0	0	0

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Day of the month.	Total quantity of water treated in million gallons.	Quantity of applied oxidizing agent expressed in parts per million in terms of potential oxygen.	BACTERIA PER CUBIC CENTIMETER.				TESTS FOR B. COLI COMMUNIS.												
			Raw reservoir water at Lower Gate House.	TREATED WATER AT:			Raw reservoir Water at Lower Gate House.	TREATED WATER AT:											
				Romine Gate House.	Summit Avenue Gate House.			Romine Gate House.				Summit Avenue Gate House.							
												Dr. McLaughlin.				Dr. Park.			
					By Dr. McLaughlin.	By Dr. Park.	1.0 cc	1.0 cc	1.0 cc	5.0 cc	5.0 cc	1.0 cc	1.0 cc	5.0 cc	5.0 cc	1.0 cc	1.0 cc	5.0 cc	5.0 cc
1	41.0	0.156	350	2	14	5	?	0	0	0	0	0	0	0	0	0	0	0	0
2	41.6	0.156	400	1	75	5	+	0	0	0	0	0	0	0	0	0	0	0	0
3	42.6	0.151	425	1	12	6	+	0	0	0	0	0	0	0	0	0	0	0	0
4	43.0	0.153	350	1	46	4	?	0	0	0	0	0	0	0	0	0	0	0	0
5	43.0	0.120	450	20	–	–	?	0	0	0	0	–	–	–	–	–	–	–	–
6	43.0	0.156	250	2	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
7	41.6	0.126	350	7	13	2	0	0	0	0	0	0	0	0	0	0	0	0	0
8	41.0	0.142	325	1	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0
9	41.3	0.149	240	1	5	9	0	0	0	0	?	0	0	0	0	0	0	0	0
10	42.0	0.151	450	0	50	14	0	0	0	0	0	0	0	0	0	0	0	0	0
11	42.0	0.144	800	2	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
12	41.3	0.151	1,100	1	–	6	+	0	0	0	0	–	–	–	–	0	0	0	0
13	41.0	0.151	550	0	15	–	0	0	0	0	0	0	0	0	0	0	0	0	0
14	41.0	0.149	1,400	0	24	8	+	0	0	0	0	0	0	0	0	0	0	0	0
15	41.0	0.153	1,100	0	5	8	0	0	0	0	0	0	0	0	0	0	0	0	0
16	41.0	0.158	800	0	8	6	?	0	0	0	0	0	0	0	0	0	0	0	0
17	41.0	0.151	900	0	8	9	+	0	0	0	0	0	0	0	0	0	0	0	0
18	40.0	0.158	1,600	0	37	16	0	0	0	0	0	0	0	0	0	0	0	0	0
19	39.0	0.156	600	0	–	–	0	0	0	0	0	–	–	–	–	–	–	–	–
20	39.0	0.167	700	0	17	6	0	0	0	0	0	0	0	0	0	0	0	0	0
21	39.0	0.165	450	5	16	2	0	0	0	0	0	0	0	0	0	0	0	0	0
22	39.0	0.144	250	0	21	6	?	0	0	0	0	0	0	0	0	0	0	0	0
23	39.7	0.074	700	30	12	8	0	0	0	0	0	0	0	0	0		0	0	0
24	40.2	0.081	450	0	–	–	0	0	0	0	0	–	–	–	–	–	–	–	–
25	41.0	0.086	350	0	12	5	0	0	0	0	0	0	0	0	0	0	0	0	0
26	40.3	0.086	290	2	–	–	0	0	0	0	0	–	–	–	–	–	–	–	–
27	40.0	0.086	280	2	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0
28	40.0	0.086	270	2	11	3	0	0	0	0	0	0	0	0	0	0	0	0	0
29	40.0	0.084	600	10	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0
30	38.6	0.084	475	0	21	4	0	0	0	0	0	0	0	0	0	0	0	0	0
31	38.0	0.081	460	0	–	–	0	0	0	0	0	–	–	–	–	–	–	–	–

ELECTROLYTIC METHOD

Some time after the sterilization plant was put into service studies were inaugurated to demonstrate the efficiency of electrolytically-prepared hypochlorite of sodium. An electrolyzer was obtained from the National Laundry Machinery Company, of Dayton, Ohio, and this machine was set up in the gate house at Boonton and studies began. This electrolytic cell is of porcelain-lined pottery clay containing carbon electrodes and glass and carbon baffles. A solution of common salt of about 4.5 per cent strength and having an initial temperature of about 65 deg. Fahr. was run through this cell at a rate of about 2 cubic feet per hour in the presence of a direct electric current of 110 volts and 22 ampères. The yield of a single cell was about 0.6 pound of available chlorine per hour.

RESULTS OBTAINED DURING A SPECIAL TEST

Between the dates March 20 and 24, 1909, a comparative test was made on the raw water to determine the relative efficiency of hypochlorite of lime in the form of bleaching powder and sodium hypochlorite electrolytically prepared. A considerable number of determinations of the bacterial quality of the raw and treated water before, during and after the use of the sodium hypochlorite solution showed that when equal quantities of the germicide in these two forms were added to the raw reservoir water the efficiency, so far as the destruction of bacterial life was concerned, was the same. The following table shows the results obtained during this test:

Results Obtained During a Special Test Run at Boonton, N. J., to Determine the Relative Efficiency of Calcium Hypochlorite (from Bleaching Powder) and Sodium Hypochlorite (Produced Electrolytically from Common Salt at Boonton).
(The Daily Flow of Water was 40,000,000 Gallons.)

Date, 1909.	HOUR. (Upper figure — hour of collection of raw water sample. Lower figure — treated water sample.	Quantity of applied oxidizing agent expressed in parts per million in terms of potential oxygen.	BACTERIA PER CUBIC CENTIMETER.		RESULTS OF TESTS FOR B. COLI IN 1 CC. OF RAW RESERVOIR WATER AT BOONTON, N. J., AND IN 10 CC. OF TREATED WATER AT SUMMIT AVENUE GATE HOUSE, JERSEY CITY, N. J.		REMARKS.
			Raw water.	Treated water at Summit Avenue Gate House, Jersey City.	Raw water. (Presumptive test.)	Treated water. (Determinative Test.)	
March 20	3:00 p.m	0.044	3,200	19	0	0	Calc. hypo. in use.
" 20	3:30 "						
" 20	4:00 "	0.044	2,300	18	0	0	" " " "
" 20	4:30 "						
" 20	5:00 "	0.044	2,900	15	0	0	" " " "
" 20	5:30 "						
" 20	6:00 "	0.044	2,700	20	0	0	" " " "
" 20	6:30 "						
" 21	8:00 a.m.	0.052	2,800	19	0	0	Sodium hypo. started 9:30 p.m., Mar. 20.
" 21	8:30 "						
" 21	9:00 "	0.052	2,600	18	0	0	
" 21	9:30 "						
" 21	10:00 "	0.052	2,800	15	+	0	
" 21	10:30 "						
" 21	11:00 "	0.052	2,800	15	0	0	
" 21	11:30 "						
" 21	12:00 "	0.052	1,800	15	0	0	
" 21	12:30 p.m.						
" 21	2:00 "	0.052	2,000	11	?	0	
" 21	2:30 "						
" 21	3:00 "	0.052	Lost	17	0	0	
" 21	3:30 "						
" 21	4:00 "	0.052	1,800	10	+	0	
" 21	4:30 "						
" 21	5:00 "	0.052	6,100	21	0	0	
" 21	5:30 "						
" 21	6:00 "	0.052	4,600	10	0	0	
" 21	6:30 "						

Results obtained during a Special Test Run at Boonton, N. J., to Determine the Relative Efficiency of Calcium Hypochlorite (from Bleaching Powder) and Sodium Hypochlorite (Produced Electrolytically from Common Salt at Boonton). (The Daily Flow of Water was 40,000,000 Gallons).

Date, 1909.	HOUR. (Upper figure — hour of collection of raw water sample. Lower figure — treated water sample.	Quantity of applied oxidizing agent expressed in parts per million in terms of potential oxygen.	BACTERIA PER CUBIC CENTIMETER.		RESULTS OF TESTS FOR B. COLI IN 1 CC. OF RAW RESERVOIR WATER AT BOONTON, N. J., AND IN 10 CC. OF TREATED WATER AT SUMMIT AVENUE GATE HOUSE, JERSEY CITY, N. J.		REMARKS.
			Raw water.	Treated water at Summit Avenue Gate House, Jersey City.	Raw water. (Presumptive test.)	Treated water. (Determinative test.)	
March 22	8:00 a.m.	0.051	5,100	9	?	0	
" 22	8:30 "						
" 22	9:00 "	0.051	3,000	12	+	0	
" 22	9:30 "						
" 22	10:00 "	0.051	3,800	7	+	0	
" 22	10:30 "						
" 22	11:00 "	0.051	4,400	13	0	0	
" 22	11:30 "						
" 22	12:00 m.	0.051	6,400	6	0	0	
" 22	12:30 p.m.						
" 22	1:00 "	0.051	5,000	1	0	0	
" 22	1:30 "						
" 22	2:00 "	0.051	2,000	3	?	0	
" 22	2:30 "						
" 22	3:00 "	0.051	4,500	2	0	0	
" 22	3:30 "						
" 22	4:00 "	0.051	4,900	2	0	0	
" 22	4:30 "						
" 22	5:00 "	0.089	3,900	3	0	0	Dose increased 4:20 p.m., March 22.
" 22	5:30 "						
" 22	6:00 "	0.074	5,200	9	0	0	Dose diminished 5:15 p.m., March 22.
" 22	6:30 "						
" 23	8:00 a.m.	0.079	2,200	6	0	0	Sodium hypo. discontinued and use of calc. hypo. resumed 11:00 p.m., March 22.
" 23	8:30 "						
" 23	9:00 "	0.079	2,700	2	?	0	
" 23	9:50 "						

Under the existing circumstances the total cost which can be charged against the process when using bleaching powder was found to be $0.14 per million gallons of water treated, this figure being divided up substantially as follows, basing the figures on an average daily treatment of 40,000,000 gallons of water:

One extra operator	$0.065
Bleaching Powder	0.065
Coal for heating the plant, miscellaneous laboratory and other supplies	0.010
	$0.14

It may be well to point out that power costs nothing at this plant for the reason that it is obtained from a water wheel actuated by the water flowing through the pipes which deliver the water from the dam to the aqueduct leading to Jersey City.

COST OF THE PROCESS WHEN USING ELECTROLYTICALLY PREPARED SODIUM HYPOCHLORITE

With power costing nothing, the charge for electric current in this process is nil. It has been found that to produce a pound of available chlorine in the electrolytic cell requires about 8.5 pounds of common salt. This salt, delivered at the plant, costs about one-third of a cent per pound; therefore, the cost for salt amounts to 4¼ cents per 1,000,000 gallons of water treated. The other figures previously given remain the same, making the total cost by the electrolytic process 11¾ cents per 1,000,000 gallons of water treated. In neither case has interest on the investment been included nor charges for depreciation in the plant. If this were added the total cost of the process would be between 20 cents and 25 cents per 1,000,000 gallons of water treated.

DEPRECIATION OF PLANT

As to depreciation in either process, it may be well to point out that, although the plant has now been in operation over seven months it has not been necessary to replace any of the piping, pumps or valves, and such repairs as have been made are not worthy of mention.

EFFECT OF THE TREATMENT ON THE CHEMICAL AND PHYSICAL CHARACTERISTICS OF THE RAW BOONTON WATER

In general terms when hypochlorite of lime or soda is added to water the chemical and physical characteristics of the water are changed to some extent. Through the action of carbonic acid, either free or half bound, hypochlorous acid is released from the hypochlorite, and this acid, although very weak, is an active oxidizing agent. In the presence of organic matter its oxygen is released and this attacks the organic matter and oxidizes it. As hypochlorite of lime is a mixed compound, composed of calcium chloride and calcium hypochlorite, it follows that the former will add to the hardness of the water. In the electrolytic process where sodium hypochlorite is produced, the resultant solution contains in addition a slight amount of caustic soda and some sodium chloride, and the hardness of the water would, therefore, not be increased by its addition to it. In both cases the total solids in the water would be increased, and the color, if an organic stain, would be reduced. The carbonic acid in the water would be reduced, since it is essential for the liberation of hypochlorous acid from the hypochlorite.

In more concise terms it may be said that by adding hypochlorite of lime or soda to a water, the organic color thereof will be reduced; there will be an oxidation of organic matter; the carbonic acid will be reduced; the total solid matter in the water will be increased and, in the case of hypochlorite of lime, the total hardness of the water will be increased. With hypochlorite of soda this is not the case. All of the above changes were noted in a series of chemical analyses of the raw reservoir and treated waters. The amounts of chemical applied were so small, however, that the differences in the physical and chemical characteristics of the water before and after treatment were so slight as to be barely noticeable and were well within the limits of accuracy of the methods of analysis.

The most important chemical change which is brought about in this process is the reduction of carbonic acid. This has considerable practical significance from a standpoint of the incrusting and corrosive action of water on iron and steel pipe brought about by the action of carbonic acid.

The claim has been made that free chlorine is liberated in this process, and that it may persist in water treated with hypochlorite of lime. This is in no sense true for the reason that free chlorine cannot be liberated from hypochlorite of lime or soda in a natural water. To do so it would first be necessary to decompose all the alkaline constituents in the water with an excess of strong mineral acid. Again, even if free chlorine could be liberated from hypochlorite of lime in a natural water, the chlorine would immediately combine with the hydrogen of the water and liberate atomic oxygen.

DISCUSSION

PROF. H. B. CORNWALL: *Mr. President and Gentlemen:* When Dr. Leal called on me sometime ago to speak about this process which he has just described to you, and which it appears to have been his notion to put into regular effect as a means of sterilizing a water suitable for treatment, he asked me two or three questions. One was whether I thought that water could be sterilized in this way. I told him that I thought that it could. He asked whether I thought there would be any objectionable results from the process? I told him that I thought there would not; but I must confess that when I was giving him these answers, although there was not any doubt in my mind upon first looking into it that they were correct enough answers, I was basing them all on a somewhat different assumption, than what has turned out to be the truth. He told me they were going to use bleaching powder. Of course, the first idea that occurs to anyone in connection with bleaching powder is that it is a very powerful sort of substance. All the manufacturers of bleaching powder and the people who are using bleaching powder invariably refer to its strength in terms of what they call "available chlorine;" and every chemist working in a laboratory knows what happens when some of his chlorine gets beyond the bounds that he has set for chlorine. He knows that it is not a pleasant neighbor to have in a laboratory.

But on looking the subject up afterwards more thoroughly I found that under the conditions in which this agent is used, whether as a solution of calcium hypochlorite made from bleaching powder, or obtained electrically as a solution of hypochlorite of sodium from common salt, it was not a question of free chlorine at all.

At the beginning of the discussion, which I am not going to prolong very much, I would say that this term "available chlorine" applied to bleaching powder is quite similar under the conditions in which it is used in the water as described by Professor Leal, to the use of the term horsepower as applied to a steam engine. There are no horses around. This is simply a way of measuring oxidizing effect. This "available chlorine" is simlpy a way of measuring oxidation. The result may be brought about in different ways.

The real agent in the wonderfully efficient process that has been laid before you is oxygen. If you will look through the standard and most up-to-date works on chemistry, you will find nowhere any other statement with regard to hypochlorites, whether of soda or lime, calcium or sodium, under the influence of weak solutions of carbonic acid—and that is what is present in all natural waters. The only acid that is present in a free state is carbonic acid. You will find the statement invariably made that a very weak carbonic acid solution does not liberate chlorine from bleaching powder or from any similar compounds. I have tried the experiment myself and could not find that any chlorine was liberated. Then on the other hand, hypochlorous acid, which is present in hypochlorite, is a very feeble acid indeed. Hypochlorous acid is a feeble compound which is pretty easily split up. It consists of hydrogen, cholrine and oxygen, an atom of each; and in the presence of anything oxidizable the oxygen splits off. The printed paper very thoroughly discusses this aspect of the case, and I will not deal with that part any further than to say that the residual hydrochloric acid reacts with the calcium carbonate that is present in the water, or there may be carbonate of sodium present in the water, very often is—almost certainly is. So it is disposed of, and we get a perfectly neutral calcium chloride and sodium chloride.

Now it has been part of my connection with this whole subject to make quite numerous tests of the raw Boonton water, and of the same water after it had been treated with the bleach. The tests were quite as full as analyses that are made to determine from a chemical point of view whether a water is suitable for drinking purposes and for manufacturing purposes. These tests were carried along with analyses to see what the result would be of this very small quantity of bleaching powder put into the water up at Boonton and how it manifested itself. Each of these tests showed exactly what you would have expected. That is, we were putting in a small quantity of soluble calcium compounds, calcium chloride, calcium hypochlorite, calcium hydroxide, which is present in the bleach, and also very small quantities, indeed quite inconsiderable and not worth noticing, of impurities present in the bleach. We found that the nitrites, which you know are present in almost any natural water to a very small extent, disappeared under the oxidizing action of the hypochlorite. The nitrates were increased very slightly. The total solids increased a little exactly in proportion as these things were put in. I do not suppose that a process like this, as Dr. Leal has very properly said, would be applicable for too impure a water even if it were to be prepared for drinking purposes. I can imagine that under such circumstances as that you would find that you had to put in a very considerable quantity of bleach. Now if for any reason, considerable rain or something of that sort—we know that rain water is at times a very pure water—you might be likely to find yourself putting in an excess of this bleaching powder, because you would not know just exactly what effect the large additional amount of rain water might have upon your water supply; but that would not be a matter of any moment when you were putting in very small quantities. You are never in any danger of getting an unwholesome excess even in the first place.

I can see that it is suitable for a water which, even without this treatment or without any treatment is devoid of taste of of any unwholesome odor. We know that the surface water that comes down from our granite mountains has no odor. This Boonton water has no odor. I have again and again tried it, and it has no odor whatever under the conditions in the summer when we are looking for it.

If you take a half liter of it and heat it, as we do in our analyses, and apply your nose to the lower part of the retort, you will notice a very slight odor; but it is not the odor of putrescence at all, it is an odor more like wet hay than anything else. It is the odor that you get with any such surface water that you collect in most parts of the country. Now to such a water as that this treatment is I believe perfectly applicable.

I am not going into the bacteriological aspects of it. The paper goes on to prove that it takes very minute quantities to sterilize the water and render it no longer harmful from any specific disease. The germs are killed.

What I would like to speak of a little bit is the question of the conceivable injury done to a water to be used not only for drinking purposes but for ordinary technical and industrial purposes by putting in a small quantity of bleaching powder or of hypochlorite.

I would remind you that when I was first examining the question, I thought of the decomposition of this bleach as giving out chlorine which would kill germs. It would, I suppose, but I do not believe it would kill them because of free chlorine. Anyone that wanted to raise objections to this process might do so on the assumption that there was free chlorine, but there is not. If there were you might expect to find a deleterious effect on metals; for instance, you will find that no iron that has come in contact with this treated water is going to be affected or corroded. Now what is the truth in regard to that? Well, after treatment the water runs through some seventeen miles of supply pipes. I have made perhaps a dozen tests of the raw water, and also of the treated water discharged at the lower end of these seventeen miles of mains; and I never found any more iron in the water at the end of the line than I did in the raw water. Generally it was just about the same amount of iron in the one case as in the other. Not infrequently there was a little more iron in the raw water than there was in the water after it had been treated and then run through seventeen miles of pipe. When you come to think of it, the corrosive action of water on metals like lead or iron is due probably to the combination of two different things; and this corrosive action will manifest itself in the test. We did not find any evidence of such effects. In order to produce this effect we must have oxygen present, also carbonic acid and carbon-dioxide and then you are likely to get considerable corrosive action.

They are putting in a bleach which contains about twenty per cent of calcium hydroxide. It contains calcium oxide; and when you put in the bleach you are putting in something that combines with the free carbonic acid. The less free carbonic acid there is, the less the corrosion.

There is no marked effect on the Boonton water in destroying color. Sometimes I have been able to observe a little less color in the water, and sometimes not any difference. When the water stands a few days in the bottle and deposits sediment, there is no difference in the character of the sediment.

My conclusion in regard to this is that the process is just what Dr. Leal has said about it, that it is just suitable for a water that is pretty nearly good enough anyway, and where you just want to make sure that you are getting rid of any possibility of dangerous germs. It is not suitable for a very impure water which you would have to treat in some other way before you could subject it to treatment with the bleach, unless you wanted to run the risk of putting in too much bleach.

I am very glad to have had a chance, Mr. President, to address the members of the Association.

VICE-PRESIDENT ALVORD: We also have with us Professor Flather, of the University of Minnesota.

PROF. J. J. FLATHER: *Mr. President and Gentlemen of the Association*: The hour is getting late and I will not impose upon your time. The subject is one of very great interest to me, as it doubtless is to you, as being something new in the purification of water on a large scale. My attention was first called to this process during the winter when my friend and colleague, Dr. F. F. Westbrook, was carrying out some experiments on the Mississippi water at Minneapolis. I was surprised to learn of the wonderful results that were obtained in reducing bacteria with such minute quantities of bleach. I was familiar with the use of alumina, and of lime and iron in reasonable quantities of from one to three grains per gallon; but when it comes to the use of a quantity of one-hundredth of a grain per gallon, I did not think it could be much good; but I was very much surprised to find that the bacteria were practically eliminated. So when I had the opportunity of inspecting this plant at Boonton a few weeks ago, I was prepared to find a duplication of these laboratory experiments on a much larger scale and was very glad to find them.

It was my privilege to be able to examine the records there for several months, and it was astonishing to find how the bacteria had been reduced from several thousands in some cases to zero, two, three, four, eighteen per cc.; very small indeed in number. In one case during the month of April, I think it was, there were nine days in which the bacteria shown was zero, something very interesting because of the very minute quantities which were used, not more than two-tenths p.p.m. up to perhaps four-tenths p.p.m. I expected to find the use of this chlorine producing possibly an odor and taste; but at that plant there was no such odor manifest, nor any taste so far as I could determine.

The use of this agent has been very well suggested as being applied to a water which is fairly good in itself. That suggests, as Dr. Leal has mentioned, a use for it in waters which have been treated by filters. I was not surprised to find in other places that this bleach is now being used for that purpose. I was informed that it was being used in the Croton Reservoir at New York; but from the records that I was able to obtain there from Dr. Park, I am sure that the bleach was not used during the month of May of this year, for the bacteria as determined from water taken from the tap ran anywhere from 200 up to 500 per cc. and I was satisfied that the bleach had not been used, because if it had been they would not have run up to such high numbers.

In other places visited I found them using the bleach very satisfactorily in connection with a filter, so as to be sure that the bacteria were reduced to the desired number.

For this purpose it is being used both with mechanical filtration and with slow sand filtration. In one case which I had the opportunity of visiting I found the bleach was applied just before the coagulated water was led on to the mechanical filter. In that case it was applied in a small quantity, about one-tenth of a grain per gallon every other day, and the bacterial content was reduced to a very satisfactory figure.

In another case the hypochlorite was applied to the effluent from a slow sand filter as it passed to the clear water reservoir.

One great advantage of the process which was utilized in this case was the ability to start the sand filter at full rate immediately after cleaning. It was found that by so doing the time out of commission was reduced from eleven to seven per cent. Another marked advantage is the ability under favorable conditions to operate the filters at much higher rates, and still have the finished water free from bacteria.

In one plant which is notable in many ways, I found the bleach being used to an extent that produced a decided odor and a very strong taste of chlorine. That was the Bubbly Creek plant in Chicago, where they were treating the sewage and rendering it practically pure. The sewage came from a sewer twenty feet in diameter discharging into a canal alongside of another sewer about four feet in diameter, and still another two feet in diameter. Some 500 or 600 feet distant the canal was tapped, and the water treated and run through a filter. Just before being led to the filter 2 p.p.m. of the active agent was introduced to the water, sufficiently purifying it to make it a drinkable water. I confess as I drank the water I had the sewer in mind back of me; but it was pure, and I had sufficient confidence in scientific results to be able to drink it with satisfaction; but there was a chlorine taste, and ordinarily I would hardly like to have that odor and taste. When the hypochlorite of calcium is used in a proper way, and when the condition of the water itself is satisfactory except for possible bacterial pollution; or when the water has already been treated in a mechanical or slow sand filter, this treatment ought to give most satisfactory results.

Prof. W. P. Mason: *Mr. President:* I can scarcely add anything to what has been already said excepting perhaps this word, that when I first came in contact with this process I was a very strong disbeliever; in fact, I am on record in print as not approving of the process. I have been converted, however, and I have been converted because of the results of many experiments. I found, very greatly to my surprise, that the dose was exceedingly small that was required to produce satisfactory treatment.

Of course there is nothing new whatever about the use of bleaching powder as a disinfectant. If we throw in enough bleaching powder all germs are killed. But I was by no manner of means prepared to find that three one-hundredths of a grain per U. S. gallon of bleaching powder, measured as available chlorine, was sufficient to do good work and reduce the number of bacteria from a high figure to nearly zero. Water containing about 100,000 per cc. was used and after the treatment the count was reduced to four, five, six, and ten. So far as intestinal organisms were concerned, they were simply wiped out. I seeded waters with pure cultures of B. coli, and also others with human dejecta. Absolutely no gas-forming organisms were secured therefrom, everything of that description was entirely wiped out. even with that exceedingly small dose. It has been already stated, and I thoroughly believe it to be true, that the consumers do not get any liberated chlorine. But as I was sitting here listening to what was being said, I could not help but think what would happen if a trace did reach them. Just for the sake of argument let us suppose that that infinitesimal dose of chlorine got to them, what would happen? I was reminded of a temperance crusade in Albany some years ago when a brother got up and said, "Let a drop of alcohol get in your eye, note how it hurts and then fancy what it does in your stomach!" An irreverant individual in the corner hopped up and said, "Brother Delevan, if you get some well-seasoned soup in your eye note how it feels!" Now everybody knows that we are constantly taking into the stomach things that we are perfectly well aware are irritants, things that we call food. We know perfectly well that chlorine in sufficiency is objectionable; but the amount under consideration here is exceedingly small. Those of us who have had a capsicum plaster stuck on us, know perfectly well that it is not pleasant; yet we use pepper on our food. Any of you that should chance to sit hard on an energetic mustard plaster would know mighty well that it was food in the wrong spot, yet we take mustard as food every day. Therefore, although I think the consumers get no chlorine, yet as I sat here listening to what Brother Leal has said, it occurred to me that the amount was so small it would not make much difference anyway.

MR. RUDOLPH HERING: *Mr. Chairman and Gentlemen:* The hour being very late, I shall only say a few words. I think the profession of water supply engineering owes a debt of gratitude to Dr. Leal, Mr. Fuller and Mr. Johnson for having developed this plan in such a manner that it can be efficiently and economically used in certain places, that it has come to stay with us, and that it is going to serve many a good purpose in the future.

It occurred to me a few moments ago that it is just forty years this month since I was employed as an assistant to design an intercepting sewer to protect the water supply of Philadelphia. That was the only method formerly used to protect the water supply. That sewer extended about six miles on the left bank of the Schuylkill River from the outskirts of the city to below Fairmount dam where the water was being taken. It was expected at that time that such a sewer would protect the water supply of the city. It was not built until many years afterwards. In addition to this precautionary measure the city bought property for a park for a distance of five miles on both shores of the river, to prevent houses and factories from being built near the shore and to keep out any sewage that might go into the river from this vicinity.

But even that did not completely satisfy the people, because today they have a system of water filtration to purify that very water which they first protected by purchasing land and making a park and then by building an intercepting sewer in addition. Filtering the water supply was the one way by which it was deemed possible to maintain its purity.

The method of disinfection which has been described tonight is of quite recent development, and I am quite sure that if it had been used in Phildaelphia many years ago, when the water supply, though receiving directly the sewage of over 50,000 persons, was comparatively very clear for most of the year, it would have saved thousands upon thousands of lives in the city of Philadelphia from typhoid fever death alone.

So I feel satisfied that a big step has been made in the progress of water works engineering; and while we cannot expect that this method will answer every case and take the place of filtration, or do away with a careful protection of the territory of our water supplies, this method has certainly come to stay and to fill a certain place.

In Europe they maintain that no water should be supplied to cities that is not either filtered by nature, such as ground or spring water, or is artificially purified by filters. In our country we are rapidly approaching the same ideas; but there are many cases where our new and not wealthy cities cannot afford to establish expensive filtration works, where river water is fairly good and drinkable. In all such cases I think we can be sure of saving many lives by the use of methods such as the one that has been described tonight, until the time comes when we can afford to go further and filter the supply.

I do not wish to imply that filtration will necessarily take the pathogenic germs out of the water in all cases, although it will do so in most cases. Where there is any doubt, then, owing to the comparative inexpensiveness of the method of disinfection described tonight, it offers in addition an almost perfect solution of the problem of furnishing a high grade water supply.

Vice-President Alvord: I am sure that there are many with us here tonight who are very much interested in this subject and from whom we would like to hear a few words. Although the hour is late, the meeting is open for anyone who has a question. Mr. Hill.

Mr. Nicholas S. Hill, Jr.: I feel that in addressing the Association tonight upon the subject of the Boonton sterilization plant I am in rather a delicate position. I have been employed as one of the experts for Jersey City. To make my position clear it may be well to state that the process which has been described tonight was offered as a substitute for the prevention of the pollution of the Rockaway River; and the question of the propriety of using this method of purification, and the question as to whether the process which has been described is a proper process, are now before a Master of a Chancery Court in the State of New Jersey; it seems, therefore, that if as one of the experts for Jersey City who have had charge of the Jersey City side of the case, in conjunction with Mr. Griffin, superintendent of water, I were to open up any discussion of the question I might be putting myself in an embarrassing position.

I should like very much to discuss some features of this process, not that I would want to discuss it in a condemnatory sense, I should rather want to discuss the method of application of the process to the purification of the Jersey City water supply. I may say that we have had with us in the preparation of the municipality's side of the case the most eminent experts whom we could employ. We have had with us Professor Sedgewick, of the Massachusetts Institute of Technology; Professor Winslow, of the same institution, and Professor Phelps, who has done probably more experimental work in the use of chloride of lime as a disinfectant than any other man in the country. We have also had with us Mr. Whipple and Mr. Goodnough, chief engineer of the Massachusetts State Board of Health. We have had Dr. D. D. Jackson, who is the chemist and expert bacteriologist in charge of the New York City water supply. The only conclusion which these gentlemen have reached has been that the application of the process as designed for Jersey City is not sufficient, is not complete; and I simply want at this time to make that statement, because I think it will be interesting to the Association to hear this question fully discussed.

In view of the fact that I do not feel that it would be proper for me to undertake such discussion tonight or to ask our experts here to enter into such discussion, I think that I can safely say that at some future meeting of this Association, probably next year, there will be prepared a statement setting forth the views of those who are engaged on the Jersey City side of the case; not, as I say, in a controversial way, not as condemnatory of the methods which have been suggested, but as throwing another light upon the process which I think would be of benefit to the Water Works profession.

MR. A. A. REIMER, E. Orange, N. J.: I am glad that Mr. Hill has spoken as he has. I think we all will look forward with considerable interest to those papers in view of the fact that there has been presented a process that seems to be an important adjunct to the subject of purification of water. If there is any possibility of getting the papers in time for printing in the annual report even though the matter may not be complete, I think it would be valuable to all of us to have them in view of the discussion we have had tonight from what might be called the anti-Jersey City side of the case. I think we should have as many details as possible of the complete case presented to us at an earlier period than next year. The case is too one sided at present to be of large value to the profession at large.

VICE-PRESIDENT ALVORD: Is the testimony in the case printed as yet?

MR. NICHOLAS S. HILL. JR.: The testimony will be printed. Part of it is printed at the present time. I do not know when a decision will be reached in this case; but I think I am safe in saying that there will be no discussion until the decision is reached in the case.

Mr. R. E. Milligan: As a mechanical filtration man this subject is naturally one of the greatest possible interest. I think I can say that all mechanical filtration men have eagerly received the information which has been given concerning the effects reached at Boonton and at other places, where either wholly experimental or practical use of the hypochlorite of lime has been made. Considerable discussion among the mechanical filtration men naturally has resulted; and speaking for myself, I think we regard the use of this agent as an added safeguard to the purification of water by mechanical filtration.

Of course mechanical filtration is used more especially with waters containing color, suspended matter and algæ. In the latter case I do not understand that results of any value have been reached as to whether or not the various algæ are affected or killed by the use of this germicide. Its application in a systematic way, as you have heard described tonight, has brought out more clearly to us than anything else the exceedingly powerful effect of the minute amount employed upon the bacteria in the treated water.

One of the speakers tonight stated that with waters that are nearly good—or words to that effect—this process unaided would be very acceptable. Of course I do not attempt to quote the speaker's words exactly. In my experience there are no nearly good waters. The employment of mechanical filtration either comes because of the desire on the part of the consumer to safeguard himself and family from accidental pollution in what is otherwise a good water, as it is for example at Ithaca, where the original water was beyond question good, yet where that terrible epidemic with which you are all familiar was due to an accidental cause; or it is applied to waters that are physically repulsive. Many of these repulsive waters are excellent so far as their bacterial content is concerned, and the reduction of the bacteria or the sterilization of the waters would not render them an acceptable supply. There is, however, as all filtration men know, a class of water that borders on the impossible from the standpoint of the water chemist, laying aside its physical aspect, because the amount of bacteria is so great. While in no sense of the word sewage, it is quite beyond the range of mechanical or any filtration efficiency. Such a water as Dr. Mason spoke of tonight in the Hudson at certain points seems to be fairly representative of that class. In these cases an additional germicidal process of this sort will undoubtedly, I am satisfied, be of the greatest possible assistance to mechanical filtration, and will be employed in my judgment on all such waters in the future as an adjunct to mechanical filtration. This will be done in the usual way known to you all, as coagulants are now fed or by the introduction of the hypochlorite of lime salt in the settling basin, or between the settling basin and the clear water well, or in the clear water well itself.

To my mind the hypochlorite process is rather one that will effect the so-called ozonization process, and will come as a practical means of accomplishing what is substantially the same thing, the sterilization of water by means of oxygen under the terms "avalable chlorine" or "potential oxygen" rather than the cumbersome and somewhat expensive process known as the ozonization of water.

Mr. Edward Bartow: *Mr. Chairman:* In view of what has been said concerning bleaching powder as an adjunct to filtration, by Dr. Leal and Mr. Hering, I would like to say a few words regarding some experiments that have been carried on by Mr. G. A. Van Brunt and myself. After the publication of the successful experiments in Bubbly Creek, by Geo. A. Johnson in one of the engineering journals, and a paper by Mr. Adolph Gehrman on the same subject before the Lake Michigan Water Commission, we started out with the intention of testing the use of bleaching powder with respect to ordinary filtration plants. First we determined the sensitiveness of the potassium iodide starch test. Finding that this test was much more sensitive than taste we thought we would be safe in trying some experiments on a larger scale at the Lake Forest filter plant. We were successful in reducing the number of bacteria, and in practically eliminating the B. coli, as shown by the presumptive test; but owing to the insufficient size of the filtration plant we gave up the experiments there.

Experiments were then made at Quincy, Ill. First I may say that we experimented on various waters, in the laboratory, namely distilled water, water from wells, and from the Mississippi river. We found that the amount of bleaching powder that could be detected varied with the character of the water. Less bleaching powder could be detected in the distilled water than in the well water and less in the well water than in the Mississippi river water. The bleaching powder also disappeared more quickly from the Mississippi river water than from the others.

In tests at Quincy we first determined what we might call the normal. For a period of ten days tests were run on raw water and filtered water. The raw water contained from 3000 to 7000 or 8000 bacteria per cc., and the B. coli was always present, as shown by presumptive tests. The filtered water contained from 200 to 500 bacteria per cc., including B. coli at times.

At the end of ten days bleaching powder was used in quantities not exceeding two-tenths grain per gallon. By the use of the bleaching powder solution placed in the system between the sedimentation basin and the filters, it was possible to reduce the number of bacteria per cc. in most cases to below 10. The B. coli was entirely eliminated.

It seems to me that this is a good illustration of the use of bleaching powder as an adjunct to filters.

MR. A. H. WEHR, Baltimore, Md.: Mr. Milligan referred a moment ago to the fact that possibly this hypochlorite may be found to answer as a substitute for ozone sterilization of water. You have heard this evening reference made to a paper by Mr. Walden, the Chief Engineer of the Company which I represent. For some months past, under the direction of our chief chemist, we have been making experiments with hypochlorite of lime, and we are now operating both slow sand and mechanical filters with hypochlorite as an adjunct to filtration. We have not found that hypochlorite is even likely to answer as a substitute for ozone sterilization of water, as is shown by the fact that we now have in process of construction what I believe is the first ozone sterilizer to be erected on any large scale in this country; that is to say we are erecting a 6,000,000 gallon ozone sterilizing plant to be used in connection with and addition to sedimentation. We expect to have this plant in operation in sixty days, and no doubt Mr. Walden can be prevailed upon by myself or Mr. Diven to write a paper for the next convention giving the Association some information about this ozone plant.

Vice-President Alvord: The hour being late, I will ask Mr. Fuller to close the discussion in a few words, if he has anything to add.

Mr. G. W. Fuller: *Mr. Chairman and Gentlemen:* I think that the field has been covered very thoroughly as we know it today. What Mr. Milligan has stated brings up one thought to my mind, and that is in connection with the removal of algæ. While my experience is limited, I am of the opinion that this is a practical method under some conditions, and perhaps it is going to prove to be a more successful treatment than copper sulphate.

In regard to the ozonization tests of the Baltimore county Water Works plant, I think that is something that we should all look forward to with great interest. We have heard of ozone of course for many years. I remember that it was discussed at a meeting of this Association in New York City; I think it was in 1901; and as I recall it there were described several European experiences such as had been ascertained by American Engineers. I think they rather led us to feel somewhat apprehensive with regard to the uniformity and the production of ozone, and also because they referred to the fact that the efficiency of the method seems to depend upon the concentration of ozone in the ozonized air. Now that is by no means an unfair statement. We do not think the situation as to ozone has improved in the last six or eight years.

I certainly believe that in the coming years we are going to see a marked improvement as to its utilization. We have not found it particularly satisfactory in the tests that I know of in this country within the last few years.

With regard to the manageability of the hypochlorite treatment as compared with the ozone treatment, as the evidence stands today I believe that an ordinary water which might be suitable for a drinking water supply can be handled readily by the hypochlorite treatment under a great many conditions, but particularly as an adjunct to filtration. What will be the future development with regard to the range of applicability of the hypochlorite treatment I think is something we will have to look forward to.

In regard to future meetings I will be very glad if we can have further light upon this matter through discussion, which may be written later and appear in the proceedings of the convention.

SECRETARY DIVEN: Was there algæ in the Boonton water at all?

MR. G. W. FULLER: There are at times, yes.

SECRETARY DIVEN: What effect does the hypochlorite have upon algæ?

MR. G. W. FULLER: They are killed, but not removed.

SECRETARY DIVEN: I tried some experiments just before leaving home. I did not find that it affected it at all. I used as high as one-fourth of a grain per gallon.

MR. A. H. WEHR: We found it had no effect upon the algæ in the reservoirs at all.

MR. G. A. JOHNSON: I want to make a short statement in regard to what I said a few minutes ago about testing the filter plant at Chicago. It is a fact that since the first of the year the superintendent has been making numbers of special tests with a view to economy. It is rather an expensive plant to operate, as I think you all may realize. At the time that Professor Flather was there I understand from Mr. Jennings, the superintendent, that the water did possess an odor that was perceptible. I was there the last time on Saturday, and at that time the odor had practically disappeared. At the present time Mr. Jennings informs me that it has disappeared altogether. He has located the source of the trouble.

MR. C. B. SALMON: I do not represent the State of Wisconsin, or the Railroad Commission, but I have gone so far as to have the commission read this paper, and tentatively have their consent to its being read here. As you know, Wisconsin gets in the limelight pretty often through its athletic politicians, in one way or another, especially during the last few years; but notwithstanding there seems to be quite an element of progress in the Wisconsin legislature, along some lines at least that look to an improvement of certain conditions that have existed in other states as well as Wisconsin, regarding utility companies. I should like to make the suggestion that if there are any questions that you would like to ask, that they be noted down in the order of the paper that I read, because sometimes a question later has to be explained by some question that should have been asked sooner.

WISCONSIN PUBLIC UTILITY LAW: ITS OPERATION AND RESULTS

BY CHARLES B. SALMON

Nineteen hundred and six found Wisconsin on the crest of a wave of municipal ownership that was sweeping generally over the country. A legislature favorable to state control and regulation of public utilities was elected. Cities immediately began an agitation, through the local press, and their representatives, for the enactment of a law that would control the rates and operation of public utilities. Numerous bills of this character were introduced in both houses of the legislature and a special joint committee was given charge of them.

The water, gas, electric, telephone and street car companies were particularly aimed at in these bills. The various utility companies of the state at once called meetings of their members to consider the situation. At first much opposition and feeling was displayed, but wiser and steadier counsel prevailed and it was agreed by the great majority of parties in interest, that the utility companies should recognize that the public had rights they were bound to respect, and an offer was made to coöperate with the joint committee of the legislature in the framing of a utility bill, which was accepted. It was intimated to the joint committee, at the outset, that no lobbying or obstruction would be attempted by the utilities, but that state control, under fair and reasonable regulations, would be recognized and accepted. In this way, a start was made in a friendly manner and the usual extreme hostility and annoying conditions were removed.

The joint legislative committee, composed of fair and liberal-minded men, with Senator Hudnal chairman, heartily welcomed the position taken by the companies and suggested a consultation with representatives of the utility companies. Members of the various interest met the committee frequently with freedom and equality of opinion and thoroughly discussed all the subjects. In this way, a half-dozen of the more vicious bills were laid aside, and all the reasonable and controlling clauses, proposed by both sides, were temporarily inserted in one bill. The most important features and the objectionable clauses were then freely and openly discussed.

The utility companies started out with two simple, but fundamental, propositions. If the state desired good public service, with oversight and control, it should give perpetual rights; and if the state wished the most reasonable rates, it must give exclusive rights. The companies argued that, without stability and perpetual rights, capital could not be enlisted and that, in order to get the best service and lowest rates for the public, there should be no competition, as that, ultimately, added a double burden for the public to pay.

These two propositions, at first, startled the legislative committee, but when it was recognized that the state would have control of rates and operation, as well as oversight in accounts and expenses, the committee could see that with perpetual and exclusive right, the public would certainly get the benefit in service and rates.

The legislative committee realized and admitted that capital would not invest in any utility business where the state absolutely controlled without restriction, and gave the corporation nothing but mere interest and that without guarantee. The indeterminate permit clause (or continuing rights) was first conceded, but was guarded for the benefit of the state by allowing the municipality the right to purchase its public utility at any time under an appraisal by the railroad commission, fair valuation being given for cost in establishing the business and for all matters belonging to and used and useful in the construction and operation of the public utility.

The state also conceded that any utility coming under the provisions of this bill should not be annoyed or molested by competition, and prohibits councils from licensing new utilities and from constructing and operating themselves a new utility, where old ones were already in operation and the service was or could be made satisfactory and adequate. Stability of investment, it was admitted, would interest capital, and exclusiveness would secure the most reasonable rates.

These points were finally admitted and the joint committee proceeded to perfect the bill that would give the state control over the utility companies, while insuring them a just and reasonable return on their property, and the present utility law is the result of over two months' agitation, consultation and agreement.

The utility bill, as finally enacted, was not, by any means, entirely satisfactory to the municipalities, because it took the utilities out of local politics and local control. Neither was it satisfactory to the utility companies, for the commission controls operation, and regulates bookkeeping, receipts and expenses; but while the vital points of the bill gave to the state the control desired, it also insured the companies a reasonable return and protected them in a just use of their properties.

The administration and working out of the bill was placed in full charge of the railroad commission, composed of three men, very able and judicious in the three departments, law, statistics and economics, which they each represented. Under them are a large force of state engineers, accountants and assistants. The provisions of the Wisconsin utility law, briefly stated, under the important heads, are as follows:

Section 1797m—1. The term "public utility" as used in this act shall mean and embrace every corporation, company, individual, and every town, village or city that now or hereafter may own, operate, manage or control any plant or equipment for the production, transmission, delivery or furnishing of heat, light, water or power either directly or indirectly to or for the public.

Section 1797m—2. The railroad commission of Wisconsin is vested with the power and jurisdiction to supervise and regulate every public utility in this State, and to do all things necessary and convenient in the exercise of such power and jurisdiction.

Section 1797m—3. Every public utility is required to furnish reasonably adequate service and facilities. The charge made by any public utility for any service rendered shall be reasonable and just, and every unjust or unreasonable charge for such service is prohibited and declared unlawful

Section 1797m—5. The commission shall value all the property of every public utility actually used and useful for the convenience of the public.

Section 1797m—8. 1. Every public utility shall keep and render to the commission, in the manner and form prescribed by the commission, uniform accounts of all business transacted.

Section 1797m—9. The commission shall prescribe the forms of all books, accounts, papers and records required to be kept, and every public utility is required to keep and render its books, accounts, papers and records accurately and faithfully in the manner and form prescribed by the commission and to comply with all directions of the commission relating to such books, accounts, papers and records.

Section 1797m—13. The accounts shall be closed annually on the 30th day of June and a balance sheet of that date promptly taken therefrom. On or before the first day of August following, such balance sheet together with such other information as the commission shall prescribe, verified by an officer of the public utility, shall be filed with the commission.

Section 1797m—15. 1. Every public utility shall carry a proper and adequate depreciation account and the commission shall ascertain and determine what are the proper and adequate rates of depreciation of the several classes of property of each public utility. The rates shall be such as will provide the amounts required over and above the expense of maintenance, to keep such property in a state of efficiency corresponding to the progress of the industry.

3. The commission shall provide for such depreciation in fixing the rates, tolls and charges to be paid by the public.

4. All moneys thus provided for shall be set aside out of the earnings and carried in a depreciation fund. The moneys in this fund may be expended in new construction, extensions or additions to the property of such public utility, or invested, and if invested the income from the investments shall also be carried in the depreciation fund.

Section 1797m—27. A schedule of all rates must be filed with the commission and a copy exposed in a conspicuous place at the office of the company. No rate can be changed without consent of the commission, or any preference or favor given to any one, either in the rate itself or in its collection, and every like customer must be treated alike. Penalties are attached which affect the taker as well as the giver.

Section 1797m—43. Complaint may be made to the commission against the rate or service of any public utility, by twenty-five persons or by any municipal council or public society, and the commission investigates the complaint by first serving notice on the corporation. Any person may make complaint under certain restrictions and conditions. Explanations and consultations usually follow, between the complainant and the corporation, at which some member of the commission or its agent are present. Very frequently the complaints arise from misunderstanding or errors in information and are often adjusted without a formal appearance before the commission. The company, also, may have the same privilege of making complaint against any unjust or unreasonable treatment or action by a city council and may ask for advance in rates if found too low.

A municipality must appear in answer to a complaint, in the same manner that the utility company appears and a utility owned and operated by a city is placed under the same restrictions, rules and requirements as a private corporation, and complaint may be made by citizens against a municipality.

All the utilities of the state, whether private or municipal, are placed under the control and jurisdiction of this bill and the railroad commission.

One of the most important clauses of the bill is the exclusive provision:

> Section 1797m—74. No license, permit or franchise shall be granted to any person, co-partnership or corporation to own, operate, manage or control any plant or equipment for the production or furnishing heat, light, water or power, in any municipality where there is in operation, under an indeterminate permit, a public utility, engaged in similar service, without first securing, from the commission, a declaration after a public hearing, that the public convenience and necessity require such second utility. No municipality shall hereafter construct any such plant or equipment, where there is in operation, under an indeterminate permit as provided in this act, in such municipality, a public utility engaged in similar service, without first securing from the commission a declaration that public convenience and necessity require such municipal public utility—

which practically gives exclusive right to the utility in operation, providing it is able to give adequate service.

> Section 1797m—76. Every license, permit or franchise hereafter granted to any public utility shall have the effect of an indeterminate permit, which in fact is a perpetual franchise.

A municipality's power over a public utility is practically restricted to its contract and police powers and is subject to the review of the commission, so that all troubles between municipalities and the utility companies, which have been the greatest annoyances in the past and resulted often in confiscatory and expensive litigation, are now referred to and are under the control of the railroad commission.

> Section 1797m—87. Every municipal council shall have power:
>
> 1. To determine by contract, ordinance or otherwise the quality and character of each kind of product, or service to be furnished or rendered within said municipality, and all other terms and conditions not inconsistent with this act upon which such public utility may be permitted to occupy the streets, highways or other public property within such municipality, and such contract, ordinance or other determination of such municipality shall be in force and prima facie reasonable. Upon complaint made by such public utility the commission shall set a hearing as provided, and if it shall find such contract, ordinance or other determination to be unreasonable, such contract, ordinance or other determination shall be void.
>
> 2. To require of any public utility by ordinance or otherwise such additions and extensions to its physical plant within said muncipality, as shall be reasonable and necessary in the interest of the public, and to designate the location and nature of all such additions and extensions, the time within which they must be completed, and all conditions under which

they must be constructed, subject to review by the commission as provided in subdivision one of this section.

Section 1797m—88. No public utility or any agent or officer thereof or any agent or officer of any municipality shall offer to give, for any purpose, to any political committee, member or employee, or any candidate or any person, any frank free service, or other privilege, withheld from any other person.

This practically covers the important features of the bill. The rulings and practice of the commission are admittedly fair and just, and a broad, liberal, unbiased judgment so far follow through all the decisions, and no appeals have yet been taken Thirteen gas and electric cases, ten telephone and one water case have been decided, in part or in whole.

Wherever complaints have been prejudiced, unfair and unreasonable, or tinctured with either personal or political feeling, they have been denied.

Wherever rates have been unremunerative, and service was good the rates have been raised—and this applies to the majority of the cases, presented.

Wherever the service has been bad and inadequate, as in only a very few cases, the commission have ordered the service made good and adequate, as they should. So far rates have been generally maintained as not being unreasonable, but minor changes are often recommended or equalized.

The fullest freedom and access is at all times given, by the commission to the utility companies, either in making or explaining a complaint, or asking advice or submitting questions, and the ability and absolute fairness of the commission is recognized by all parties. The commission is the big, strong friend of both the utility company and the municipality, and whom neither desires nor dares to attack without cause. The law, we believe, will work out much good for both the state and the utilities and should be carefully considered by other states, as offering the best solution so far advanced for fairly settling the most vexed question—public utilities.

In closing, three all important items are left, and on which the whole bill hangs, so far as the utility is concerned:

VALUE, INTEREST, AND PROFIT

Under the law every public utility operating in the state can surrender its franchise, and become possessed of an indeterminate franchise or permit by which it continues to do business in perpetuity, on condition, however, that at any time the municipality may, upon due notice, and as provided in the law, acquire the utility in a valuation established by the commission, subject to the right of appeal to the state courts.

So far, the commission in making a valuation has taken under consideration all elements of value, used and useful, tangible and intangible.

In the Cashton Light and Power Case decided November 28, 1908, it was held in the findings of the commission regarding going value—

> That in placing a value on the physical property of a plant, the units of a plant should not be valued as independent entities, but as units of a going concern performing utility service.
>
> That the element of going value created by the investment made in developing the business and in addition to the cost of the physical structure, must be taken into consideration in fixing value.

This is the only case so far decided where going value has been taken up and decided as a separate part of the value of a utility.

The commission, in commenting upon the subject of good will and going value, rather incline to leaving out the general idea of good will, which carries the meaning of the value of a business or business stand or name because of the location, sagacity and shrewdness of the owner or builder up of a business in competition with other like businesses, but does accept the going worth of an established business, having an active and live business attached, over a new business just starting out without revenue or business.

The commission says:

> There is, however, an element of value that must be taken into consideration in estimating the value of the property under consideration, and which is sometimes spoken of as akin to good will, namely the "going value," and although the franchise of the public utility has expired, its plant is to be taken over by the village as a going concern, and just compensation must be awarded for the property taken as such, that is, as a living and operating entity, engaged in serving the public, and not a mere plant without patrons.

The commission cites the Kansas City case and Justice Brewer's decision in awarding more than construction and physical reproduction value; National Water Works Company vs. Kansas City, 62 Fed. 853; the Gloucester case, 179 Mass. 365; the Kennebec case 97, Maine 185, and the Cedar Rapids case, 118 Iowa 234, all recognizing going value as a part of and a distinct value to be added to a plant.

The commission also refers to and quotes quite freely the opinion and definition of going value, as held and used by Benezette Williams, J. W. Alvord and others in the Dubuque and other cases, so that it is fair to assume going value is now recognized by the commission as an element of structure value, and as a part of the value of a plant, as distinct and real as the pipe, buildings and machinery.

We come now to the two last vital things, interest and profit. The commission have not up to this date—May 1909—made any decision concerning interest and profit as separate items. In the La Crosse case they allowed 10 per cent for interest and depreciation. Later in the Merrill case they allowed 13 per cent to cover interest and depreciation for the purpose of calculating the difference in certain rates, but as depreciation depends largely on local and separate conditions, the rate for interest allowed cannot be figured. In no case yet has a profit separate from interest been decided. *Why should not a profit be allowed as well as interest?*

What is a fair and reasonable interest on the value of a utility? Certainly more than ordinary interest must be allowed, for that can be had without any personal attention, and double the security given for the amount loaned, whereas if ordinary interest is only allowed, and the money furnished for the total value, the security is weakened and there is no reserve value in the security to make good a loss.

In addition there is still a further risk: the owner of this loan must stand ready to put up more money, and keep putting up, without proportionate additional security, as the city grows.

It would therefore be admitted in any other commercial transaction that a liberal interest, over regular interest, should be allowed, for the added and increasing risk of this investment in maintaining and keeping it up to the demands of the public.

In addition then to a good interest on a plant *what should be allowed for a profit on the outlay?*

Where personal credit and responsibility are obliged to watch, and care for the investment, and keep up and operate it, a reasonable profit should be allowed.

What of the moving spirit, that keeps up the whole enterprise, and provides the mental energy to guide it through the uncertain and unseen happenings, that always occur and cannot be guarded against? Where is the pay for this coming in? Salary will not pay it, or be allowed to. Interest will not pay it, because the mere care of money does not require the constant watch and strain that the keeping alive of business demands.

The further fact, that the public or the state do not assure or guarantee the interest, or even any profit, but still control your business to the extent of saying you cannot be allowed more than a certain fixed income, should make it a burden on the conscience and judgment of the commission, that a reasonable interest and a fair remuneration in profit be permitted. As a matter for discussion I ask you gentlemen what should the interest and profit be?

DISCUSSION

Mr. Wm. Larsen: I understand that the privately owned utilities are to be valued as well as those that are not under the public utility bill, not a party to it in any way and have not come under it; but they are to be valued the same as those that are working under the public utility bill. If that is so, when are they to be valued?

Mr. C. B. Salmon: Every utility company in the State of Wisconsin is to be valued just as soon as the Commission can get at it. They are valuing first those against whom complaints are first made; but every utility will be valued whether it has accepted the utility bill, or not. That applies to both municipal and privately owned plants as well.

Mr. Wm. Larsen: I would ask further, for the information of privately owned and corporate plants, whether the balance of the other utilities that are not working under the public utility bill are obliged to make as complete reports as are called for in the pamphlet?

Mr. C. B. Salmon: As I understand it, every utility in the State of Wisconsin, whether they come under the act by their own volition or not, are obliged to make out these reports, and are obliged to conduct their business accordingly. They are not obliged to give up their contracts with cities for hydrants, but those voluntarily accepting the terms of the act and its provisions, do give up their franchise entire, and take in its place the Indeterminate Permit provided in the act; that is, they come under the complete control of the commission, and are not subject to the council except as provided. The hydrant rentals and domestic water rates are all reviewed on the basis of the values set by the commission on the utility. Pending your valuation you go on charging the same rates, both for hydrants and domestic service, as under your franchise. When valued, your return is allowed and your rates may be lower or higher, as the conditions and facts may determine.

If you do not apply to come under this bill [which in my judgment you sooner or later will have to in all the vital points] you are not obliged to accept the bill so far as your contract or franchise is concerned. If you have a contract wth the city that you are only to throw so many streams of water to a certain height, and your contract is not out, and that they are to pay you so much hydrant rental every year, and you do not want to take advantage of this Utility Act, you can stay out and you can still enforce that contract.

Mr. Wm. Larsen: What is considered a reasonable or average percentage of depreciation value on cast iron mains, either by number of years, or by percentage as compared to when they were laid?

Mr. C. B. Salmon: The commission's engineers, where the soil is gravel, sand or of like geological formation, are giving the life of standard cast iron pipe as one hundred years, and on plants of twenty years old, where the coating of tar is still on the inside and outside of the pipes, as is the fact in most of these cases, they give ninety-eight per cent present valuation, or two per cent depreciation. Of course, if there is any incrustation or rust, or anything like corrosion on the pipe, a further deduction is made. Some have been depreciated twenty per cent, where there were good reasons for it.

Mr. Phil Carlin: I would like to ask Mr. Salmon whether in the event that a municipally-owned water plant is allowed to run down, if this commission, as he understands it, has the power to bring such water plants up to the standard; if so, where is its revenue to come from?

Mr. C. B. Salmon: That condition has not arisen, but that question has. I want you to understand that I do not represent anybody but myself. So far as I am able to judge, if any of your members are connected with a plant in such a conditon, and the commission after examination find your water supply is insufficient, your fire pressure is poor, your water is bad, you get right to work and fix it up; that is the first thing they will say to you. After a reasonable length of time has gone by, and complaint is made that you have not complied, in that case I think they would send their own engineers or in some way pass some kind of an order, of course subject to appeal to the courts, obliging you to fix that property up, if the utility was privately owned. I think about the first thing that would be done by the city, under those conditions, would be to withhold your hydrant rentals as a part of the penalty for non-fulfilment of your contract. A fair return on the required investment would be allowed and rates fixed to make it up.

Mr. Phil Carlin: Suppose that some of the rules laid down by this commission were broken; for instance, giving water to any one of the officers or employees of the plant without pay, what is the penalty attached?

Mr. C. B. Salmon: In one section I remember it is a misdemeanor and there is a penalty of a short imprisonment or a fine of $50 to $500. No water is allowed to be given or sold to anyone at a less price than other like service is charged. An officer of a utility, public or private, might have water free if the records show such free water was made a part of his salary.

Mr. Phil Carlin: That is enough. I do not wish that in Sioux City where I live that we had anything of that kind. Our plant is carried on under a system of trustees, who appoint the various officers and employees. Our system is metered completely. Every tap that we have has a meter, and we all pay for water, superintendent, trustees, and all. There is not any one that gets water free at Sioux City.

Mr. J. Caulfield: I should like to ask a question with reference to one water department in Wisconsin. As I understand it the Railway and Warehouse Commission decided that any consumer could demand a meter, and any kind of meter that would stand the test and that department or company would have to furnish that meter free of cost, and that they are not allowed to charge any rent for same. If that is universally applicable any town or city can practically bankrupt a company. They could form a combination, and every citizen could demand a meter, and make the company purchase it, and practically reduce the revenue of the company to such an extent that the company would get no return from their investment. In a municipality it would be hardly fair for the taxpayers to be required to purchase meters for a consumer that would probably pay two or three dollars a year.

Mr. C. B. Salmon: I think your conclusion is wrong. That decision went to this point, that the company should furnish the meter, but that they would have a right to charge an annual rental which would cover its care and maintenance, and also a fair return on the investment, including depreciation and the wearing out of the meter. I would say there has been a bill recently enacted—I do not know even if it is published, that goes a little further, it is so worded that it would be a fine chance for lawyers on either side. It goes to the point of a utility owning and controlling everything up to the house, including the meters; but very wisely the last end of the bill says it is subject to the rules and provisions of the railroad commission. No water consumer should be permitted to pay two or three dollars per year. In no water service, on any utility would that begin to pay the first cost of "ready to serve," even before he took any water. A fair proportion of the general installation cost of the utility should first attach to each service, prorated on the cost or foot basis.

Mr. C. W. Wiles: Has there been any ruling on the minimum meter rates?

Mr. C. B. Salmon: That has about driven us all crazy on the ground that it does not seem fair that the large minimum rate should apply to a small house one opening consumer; neither does it seem fair to the utility that the low minimum rate of a one-faucet or one-opening consumer should be given to a man with four, five, eight or ten faucets on large premises, because when this "readiness to serve" proposition is figured you are liable to be called on suddenly for a short time for a good big lot of water to be used on those premises. That is the trouble right now. I do not speak for the commission, but I know something that is going on. The trouble right now is, what is a fair minimum rate, can we establish one minimum rate to apply to all services without being unfair to the poor, or small user, or if you establish it for him, do you not make it unfair to the utility for the large opening and "readiness to serve proposition"? I believe there should be a graduated minimum meter rate based somewhat on the openings.

Mr. D. H. Maury: I would like to ask Mr. Salmon one question, as to when or how these municipalities or public utility corporations would come under this law. Do I understand that the time within which they were entitled to come in expired last July, but that there was something on foot to extend that? You said that in the future they would all have to come in, sooner or later, if I understood you correctly, but that until that time the rulings of the commission did not apply for those having contract for hydrant rentals. Perhaps you did say that it did apply to those having such contracts, but that it did not apply to the extent of abrogating those contracts. Now if this commission's rulings do not abrogate those contracts, how are the corporations of municipal departments affected by the rulings of the commission? Do they balance up any inequity in those contracts by raising or lowering their rates? Or in what way do they come under the rulings? If existing contracts cannot be affected by the commission, and yet the commission is to take supervision, where is the line drawn, how do they reach a conclusion?

Mr. C. B. Salmon: If you had not taken advantage of applying to come under the operation of the law, and giving up your franchise, up to this time, you are in this condition; the railroad commission will not interfere with your contract with the city, because they cannot as a matter of contract; but you will not be able to receive any of the exclusive benefits of this utility act. If you have a council that wants to pass an ordinance granting some other electric light company, or some other water company, a franchise they have the power to do it. There is also a bill in the legislature of Wisconsin, that looks to putting all of the utility companies in the State of Wisconsin under the provisions of the rules of the railroad commission, whether or not they wish to. That question of course might involve some legal proposition, but the companies that come in and accept this utility bill are protected against competition, and they are protected against the danger of their franchise expiring. You can see what that led to at Sioux Falls. Their ordinance ran out, and they could not get another one and were ordered by a Federal judge to cease operating. If a company does not wish to take advantage of this provision for perpetual rights, when their franchise runs out, unless some other law is passed or the order annulled there is nothing to prevent any common council in any state for that matter from simply telling you to get out of the streets.

Mr. D. H. Maury: The situation is still not clear to me. Perhaps I have not stated my question clearly to you. I understood you to say that this commission was going after every public utility?

Mr. C. B. Salmon: I said they were going to value every public utility.

Mr. D. H. Maury: Then they are not necessarily going to bring every public utility under their rules?

Mr. C. B. Salmon: Not unless they accept the provisions of the bill. But they are going to value every utility, and it is fair to presume that with all of these ethical and new advanced opinions going on in the legislature of Wisconsin, that finally they will land, if there is any law to let them, by bringing every utility under the bill whether they want to or not, if such a law can be upheld.

Mr. R. R. Parkin: I presume that your city would have a provision that no indebtedness can be placed on the city in excess of a certain per cent of tax valuation?

Mr. C. B. Salmon: That of course exists everywhere under the state law.

Mr. R. R. Parkin: If your plant is run down you are not going to make the municipality improve that plant if they are taxed already up to the limit allowed by provision of the state law?

Mr. C. B. Salmon: You can be sure that if some municipal plant is not giving its people good water and plenty of it that there will be some state provision enacted not only allowing but compelling the municipality to furnish the proper supply, perhaps under local ordinances, and perhaps under a general state law.

A Member: Has there been any ruling of the commission on the subject of a fair remuneration for the care and reading of meters and the interest on investment in meters?

Mr. C. B. Salmon: No sir, that question is yet entirely undecided. The commission, I believe, has not yet secured the proper information to form a proper judgment to put every water company in the state on a meter basis, together with expense allowance for same.

A Member: And prescribe rents?

Mr. C. B. Salmon: I think eventually they are going to oblige the utility companies to make meters part of their investment; but they will be allowed a fair return; they will be allowed depreciation; they will be allowed a care and rental charge. Perhaps it will go to the extent of allowing the company entire supervision into the house, but allowing individuals to buy such and such meters as may be established by the company as good and safe; and if they do not want to buy such they will have the right to charge for them a fair rental which will include depreciation, care, reading, bookkeeping and all that; and I rather suspect myself that all the water companies will be put on a meter basis although it may be some years before they accomplish it.

Mr. Phil Carlin: I can see where a water works company can exist under the rules of this commission; but I cannot see where some municipalities are going to exist from the fact that the city would have gotten up to its limitation as far as taxes are concerned, they would have to stop right there and would be unable to make improvements or increase the plant, because they would not have the revenue. If operated by a company they would perhaps go on and make extensions; but it would not be possible for some cities to do it.

Mr. C. B. Salmon: The state could do it. Chicago stands ready to raise its taxation limit and has asked legislative power to do it.

Mr. A. A. Reimer: A large private company, or a large municipality, owning a considerable area of water-shed, has taken out a charter to operate for supplying water, and has protected itself under the state laws by controlling considerable more area of water-shed than is absolutely necessary for the immediate future; and say then that a smaller municipality or a smaller private company needs more water-shed area; is there any provision in this law whereby the commission can take from the larger municipality or private company and give some of the rights held by the larger corporation or municipality to the smaller?

MR. C. B. SALMON: I think that question has not yet come up, but I think that in that case the smaller company would have the right to ask the larger to sell them water, but it would sell them water at a good fair return. They will have the right to buy that water from the larger company if it has secured all the available water rights and they shall be obliged to sell it to them. A company in Wisconsin may own stock in another company. A company in Wisconsin may buy all its water from another company, or have another company pump all of its water; but in all such cases there enters the matter of fair return.

MR. E. W. BEMIS: In listening to the paper I would call attention to many things in the utility law which I think are admirable. It seems to me that every thing that bears on the municipality's service and methods of accounting is greatly needed; and in fact I suppose that that same remark would apply as to most of the applications of the law to private companies. There are two or three points, however, to which I would like to call attention. It has been suggested that under the interpretations of this law, that is perhaps being made, the companies will have a right to capitalize going value. In one case it has been referred to as equalling about 25 per cent of the total, which would mean an addition of one-third of the physical value outside of the plant. Many municipalities will argue in this way: They will say, we issue bonds for a plant. The city goes on. In course of time our plant has a going value; but we do not have to issue any more bonds, and we do not issue any more to represent the going value. The community gets the benefit of it; and the same with regard to other elements of value perhaps, such as the value of pavements that they have laid on the street after the mains are laid. Then again the city might argue that they had to borrow at 4 or 5 per cent, and the company might be given a rate of 13 per cent, as has been suggested. On the other hand a municipality has to face the claim often that it does not have as good engineers and does not have as good financial foresight as many private companies, and does not operate its plant with as much efficiency as it should; but after all many municipalities will come to the conclusion that they are improving in those directions, and they will see that it is no longer true as it used to be said, that with the same efficient management a private company is better than public operation. With the same efficiency of management the private company is handicapped in dealing with the consumer, because the private company is getting rates based on perhaps 50 per cent greater capitalization; but that handicap will not become clear of course, until you have a fair degree of efficiency in municipal work. Many cities will think such a condition never will come. There are cities, however, that will feel that it has sufficiently come so that they can afford to go ahead with municipal operation. They might apply to this commission for municipal operation so as to absorb the future growth and good will and secure a lower rate of interest on the investment.

Now, as I understand it, the state commission would not consent, after the company had registered under the law, if they thought the private company could be brought to give such a quality of service and general excellence of management as would seem to the commission to be satisfactory. There might be a great clash of opinion between the commission and the city on the point as to whether the city would find it profitable to go ahead.

Now this does not, of course, touch the question of whether the municipality should not pay a proper price for the plant, perhaps a price fixed by the commission. Then the question would be whether the commission has the right to veto municipal purchase. If that be the case, as I understand the paper, I fancy there will come a time in the future in Wisconsin when there will be quite a clash between the movement toward municipal water works and the commission theory. I should like to find out from Mr. Salmon whether I have correctly interpreted his remarks about the veto power of the commission, and also what he thinks of the suggestion that with equal efficiency of management, private management under this law would be fatally handicapped financially?

Mr. C. B. Salmon: Well, I do not know who I am running up against. I want to correct a little impression that you may have received. There has been no decision by the railroad commission as to the rate of interest allowed, or interest and depreciation as separate items. Now whether depreciation forms the larger part of that amount, or whether it is interest, I do not know.

I would like to be permitted to also suggest some matters that possibly might come up in the valuation of municipal plants. I think somewhere they will be obliged to pay taxes; I do not mean to actually pay them, but somewhere they will be obliged to account to the public for the money that is lost to the public through their not paying taxes. Somewhere they will be obliged to account for the interest charged on their investment, not on what they may have borrowed, but for all the investment.

I anticipate also that they will be obliged to keep their plants in perfect condition under this commission, the depreciation in many cases being very large; and they will be obliged to charge the city officers and the city for every bit of water that is used. That may be a little to their advantage. On the other hand they will be obliged to pay for every thing they have done. If some policeman is turning on and off water for them, if some city clerk is doing some business for them, if some city treasurer is collecting their bills—and this is something that any one can find out by a little investigation—I think all those items are going to be chargeable to the municipal plant just the same and in like form, no larger, no smaller, and under the same conditions as they are now chargeable and are now being charged in the operating of private plants.

Now as to the difference in interest charged, the city has an advantage; but I wish to say right here that from what considerable experience I have had in buying and selling and placing bonds, I think that a utility bond in the state of Wisconsin after the commission has once passed on the value of a plant, will rank equal with most railroad bonds, and instead of a five per cent utility bond being at a discount, it will be at a premium.

Mr. D. H. Maury: I think that one point that is suggested by Mr. Salmon's reply to Mr. Bemis is, in regard to the difference in interest on bonds. A municipal bond draws a smaller interest, of course, and those bonds generally cover the whole plant.

Mr. C. B. Salmon: The whole city.

Mr. D. H. Maury: Whereas no security company would dare to take a bond issue under present conditions on anything like the full value of a plant. It would not be making a proper investment. If bonds were issued on the whole plant they would have to be issued at a high rate of interest, in order to counterbalance the unstable nature of the security.

Mr. C. B. Salmon: That brings up one point that I want somebody to be thinking about whether they answer it, or not. Today, after our late money unpleasantness of the last two years, we cannot go to a bond house even with ever so good a proposition in the way of a private utility and borrow to exceed sixty-six per cent of the engineer's estimate of the cost of the utility. If I go to a bond dealer and say, "I have a plant that has now cost $300,000; it is well situated. How much money will you loan on it?"

"I will loan you $200,000, possibly $225,000."

"What will you charge for the loan of $200,000?"

"I will charge you 5 per cent. For $225,000 I will charge you 6 per cent."

Then I go over to another dealer and I say:

"I want to borrow $75,000 to finish the works."

"What have you got?"

"I have not got anything. All the security is pledged."

Now what have I got to pay for this extra $75,000 to complete my plant? That bears really on the point of low interest. I have got low interest on a portion of it, but how am I going to get that other $75,000 with every thing already mortgaged? The broker says, "The only thing I can do with you is to take a chance with you, and if I take a chance with you I have got to charge you as high as 25 per cent, 30 per cent, or 50 per cent for the money, or else you will have to give me a great lump of stock." Those are the conditions that exist with a utility company privately owned. That will have to be recognized. That is why I ask the question as to what this commission should allow for an average profit and fair return on this kind of property. The city has got to allow something more than a fair rate of interest, because the fair interest only applies to the first loan made. The second loan made is taken on a chance, and is not given a fair show.

Mr. S. B. Russell: I want to ask Mr. Salmon what checks have been provided on the expenditure of money for investment in plants.

The principle you act under in Wisconsin is that sufficient money shall be invested in the plant to provide the necessary service, and that after that is done, a fair return will be allowed on the investment. Now we know that in some cases money has been expended where it was not really necessary. To illustrate, there might be a plant supplying the necessary water where a fair return rate was more than satisfactory to its owners, and so they would like to put in a filtration plant so as to get more of the fair return, while disinterested judges might know the filtration plant was not necessary. To put it another way, it might be that at the rates allowed it would be profitable to make the investment as large as possible. Has that point been thoroughly considered? If so, how does the state expect to regulate such matters?

Mr. C. B. Salmon: If you have a supply that is supplying plenty of water you would not be allowed to buy a farm adjoining, attach it to the supply and ask for a valuation of that whole property as a water supply. Neither would you be allowed to build a business block and call it your office and ask for a valuation on that business block. . The commissioners are right up to date; they know about what is required and what is necessary. On the other hand, if you come under the provisions of this bill and you have yourself previously employed the money according to your best judgment up to that time you will find that the commission is very liberal and fair. If you have got perhaps more impounding reservoirs than you actually need; if you have bigger pumps, bigger power and bigger buildings than you actually need, if you have done it with your own money with a view to the future, they are going to allow it; but they will not allow you to enter into some subterfuge and add to your other property in order to get a big return on it, or take it and sell it to the company when it is not in any way needed. The commission take a wide look at the merits and justness of any expenditure required or already made by any utility. If in the earlier years some things were done in good faith and by the advice of the then best knowledge and experience, even though the success was not all that was anticipated, I believe they will recognize such honest expenditure and give it fair value. The fact that mistakes are made in all construction business will, I believe, find a fair allowance in their values.

NOTE: Further discussion at this time on Mr. Salmon's paper was postponed till a paper by Mr. Alvord was read; as it was thought that the two papers could be discussed together. Unfortunately Mr. Salmon was called away and no further discussion was had on his paper; this was particularly unfortunate, as a number of members still desire to ask Mr. Salmon questions and to hear further explanation of the workings of the Wisconsin Law.—SECRETARY.

MR. J. W. ALVORD: Mr. President and gentlemen, I very much regret to impose upon you at this time when I know so many of you are gathered here to take part in the selection of the next convention city and other matters. If it had not been for the motion just passed I would have suggested that the paper be passed over until some other time; but I will defer to your wishes in the matter.

In preparing a paper on the subject of "Going Value," it was my original intention to make the subject so clear that it might easily be apprehended by the mind of a tender and guileless child. I read the paper over after its completion, and I was in a little doubt as to whether it was a treatise on the Isness of the Where, or the Nothingness of Yet-to-be. I am sorry for you. It is now my strenuous duty to inflict this paper on you, but in so doing I can only say that I should like to repeat the last part of the formula usually used by the judge in sentencing a man to be hung!

NOTES ON GOING VALUE AND METHODS FOR ITS COMPUTATION

JOHN W. ALVORD

Going value is a subject which has caused much trouble to many appraisers, attorneys and even courts. It is a term of comparatively recent origin, as applied to water works cases occurring, in a Supreme Court's opinion, a little more than ten years ago. It is perhaps best understood by those men who through professional opportunity are under the necessity of originating or passing upon valuations, either in appraisal boards or in proceedings in the courts. Going value is at present the source of much difficulty to those who have not given it a good deal of thought and study.

The underlying causes of this difficulty are undoubtedly due to the following reasons:

1. A lack of clear ideas as to the underlying philosophy of the method of estimating values by "*reproduction.*"
2. The common supposition that "reproduction" is a simple method of valuation.
3. The prevalence of the idea that going value is a value quite separate and distinct from other forms of reproduction values.
4. Failure to give the subject of going value attentive and thorough study.
5. The inability to find available a really complete and lucid explanation of the method by which it may be determined.

This paper is therefore somewhat reluctantly submitted as an attempt at least to throw some light on the subject. Due acknowledgments should first of all be made to the many able legal and engineering minds with whom the writer has happily had the good fortune to be associated, and from whose able discussion and elucidation of the subject he has drawn much of the reasoning which is here set forth.

It is desirable, as a preliminary to any consideration of going value, to examine in some detail the underlying philosophy of estimating values by means of reproduction, for without such preliminary study we can hardly hope to acquire a fair understanding of going value itself.

PHILOSOPHY OF REPRODUCTION

The method of valuing a plant and property for the supply of water or other like utility, most favored by courts and appraisers, proceeds on the theory of an imaginary reduplication of the property at prevailing prices for materials and labor, less the estimated depreciation of the existing plant. This method necessarily involves as a mental process a re-creation step by step of what may be termed a *conceptual starting plant*, that being gradually built up as a mental picture by the aid of experience, local information and trained imagination, will eventually duplicate in its final form and detail the existing or going plant.

In this attempt to re-create, step by step, as a mental concept a parallel panorama of the construction of any existing plant, it is obvious that practicable working time is vital to the proper estimation of the cost. Time being always directly involved in items, such as " Interest on Investment during Construction," Cost of Administration," and indirectly involved on other items such as "Cost of Material *Delivered*," and the "Price of Machinery *set up*," "*Concrete in place*," etc, neglect of proper time assumption at every step of the way will be fatal to a full and just duplication of values.

The courts in favoring the reproduction theory have been influenced in part by the seeming simplicity of the method. It is to be doubted if this seeming simplicity exists. In practice the method logically requires many refinements some of which are quite complex. Calculation of the cost of reproducing the business and income are perhaps the most complex of its requirements. Could. plants, property and business be instantaneously created by rubbing an Aladdin's lamp, cost would obviously be wonderfully lessened and, to the extent that an Aladdin's lamp is introduced into valuations, so far are such values made thereby incomplete, impractical and unjust. The theory of reproduction, if it means anything, means painstaking consideration of the time taken in each stage of the progress toward the completion of the structure and property, and its effect upon the resulting cost, all of which has to be mentally imaged and computed closely in accord with practical working under practical limitations by an experienced and capable mind.

A full understanding of the importance of time in valuations based on the reduplication theory will clear away some of the misunderstandings occasioned by unexpected items and will lead to a more intelligent appreciation of the reasons for and the methods of computing what have been called the intangible parts of a plant and property.

PHYSICAL VALUES

The conception of these intangible values will be made more clear if as a preliminary we follow through some of the conceptual steps in the reproduction of the physical part of a plant. Some of these steps which are more or less self-evident may be stated as follows:

1 In estimating the cost of reproducing a plant, it is obviously important to consider the reproduction as taking place in a way that is *humanly possible.* Now, it is not humanly possible to construct a plant in the past, or in one day, or by the substitution of hindsight for foresight; therefore, if we are to avoid flights of constructive fancy, we are compelled to consider the reproduction as taking place in the near future in reasonable and workable periods of time, and without special foreknowledge other than that gained from experience with similar construction and familiarity with costs in the near past. To do other than this will not be "*reproducing.*"

2. A conceptual starting plant which is in process of being estimated must be made to pass through all the preliminary phases of mental origination as well as physical construction; it must consider the time and cost necessary to devise, conceive, design, negotiate, administer and direct, as well as the labor cost of digging and building, and the duplication which we try to imagine involves the re-creation of many subordinate structures, appliances, and much machinery which will have been removed or will have ceased to exist, but which were necessary in their time and place in order to bring about that finished condition which finally appears.

3. The conceptual starting plant must of course finally precisely accord in form, dimension and extent with the existing or going plant under consideration; in other words, the estimator has before him full-sized and lifelike plans and specifications furnished by the existing or going plant. This very completeness of data often tempts even experienced estimators into a neglect of the intermediate steps by which such plants are originally evolved.

4. The conceptual or starting plant should, as a matter of fairness, deal with all difficulties known to be originally encountered in constructing the existing or going plant, notwithstanding such difficulties might now be easily modified or eliminated by a forewarned intelligence.

5. The value of the conceptual or starting plant should be computed upon such prices of labor and material as it would seem safe for a prudent man to commit himself to and for such reasonable period in the near future, as experience shows will properly be required for construction. Such period in any new construction cannot of necessity be contemplated as completed in the near past from the date of the estimate, for to consider such prices as of a period that has already passed would be taking advantage of knowledge not humanly available to the ordinary constructor. Prices in the near future, however, should of course be predicated (with good judgment) upon those of the near past, just as in any practical case of new construction.

6. Certain values are largely determined and influenced by the time assumed to be taken for construction; the following are typical examples:

1. The Preliminary Costs of Organizing and Conceiving.
2. The Interest on Investment During Construction.
3. The Administration Cost During Construction.
4. The Engineering and Supervision During Construction.
5. Delays and Contingencies During Construction.

Such items are of necessity added to the cost of the plant during construction. Some of them will in time become operating expenses, but until operating revenue is available they must be added to the invested capital.

7. The method of valuing at some present date by the repro-

duction theory will necessarily include all the appreciations in value which logically and properly ought to be credited to the existing or going plant, by reason of its age. Some of these appreciations are readily admitted, as, for instance, "Increased Value of Land" due to a city's growth, but other items quite as logical are sometimes unexpected, as, for instance, the increased cost that will be necessitated in relaying pipe under pavements.

8. If appreciations are thus made necessary in the process of duplication, it is also true that on the completion of the conceptual starting plant it must be reduced in value by the measure in which the existing or going plant has depreciated through age, wear and tear, by reason of new inventions, changes in demand, growth of ideas and other fluctuating conditions. The time element here is of vital importance.

INTANGIBLE VALUES

The above outline of some of the principles which guide a practical estimator in dealing with physical property does not exhaust this part of the subject, but is sufficient to disclose the importance of the time consideration necessarily involved, and leads up naturally to a more intelligent appreciation of the more intangible values in which the time element plays an increasingly greater and greater part. Continuing, therefore, the conceptual production of the starting plant, we come to the question of estimating the cost of reproducing the business and income of the existing plant, commonly known as the going concern value.

This leads us to these further considerations:

1. It is not to be overlooked that, while the conceptual starting plant is thus being built up step by step, the existing or going plant is earning revenues, which (less operating expenses) are, of necessity, largely if not wholly lost to the conceptual starting plant.

No condition can be imagined which is practical and humanly possible which does not result in these disadvantages to the conceptual or starting plant. The actual construction of a real duplicate or rival plant would not escape this practical result, except by the introduction of Aladdin-lamp methods of reproduction. If we ignore practical time limitations in the recovery of an income, we violate all those practical conditions under which we have properly so far endeavored to proceed. If the theory of reproduction is adopted at all, it must be logically carried out, and if logically carried out in a manner humanly possible, such losses cannot be neglected. A municipality facing the question as to whether it will be better policy to purchase a private utility company's plant, or build one of its own, faces the practical question that it *will not receive the revenues during such construction* if it decides to build instead of buy. There is no escape from this dilemma, and, as a practical proposition and as sound business policy, it can usually afford to pay for the existing plant the larger part, or even all of these net revenue losses in addition to its other costs.

2. Further, when the physical property of the starting plant is completed within the constructive time assumed, the estimate of its property value for comparatve purposes is not finished, for only then would it be humanly possible to begin the work of reproducing the business and income of the existing plant, and until this is done we have not completed our reproduction.

DEFINITION OF GOING VALUE

3. Going value may therefore be defined as the value of a created income, or, to put it in the language of the theory of reproduction, it is the *cost of reproducing a given income.*

4. Therefore, in using the theory of reproduction, it is as proper and just to estimate the cost of reproducing the income of the going plant and property as the cost to reproduce its pumps, its pipes or its structures.

5. Thoughtful consideration of going value shows that it has no existence without earnings; it is inherently derived from consideration of the efforts to create revenues. Thus, a plant may be losing money and still have a going value, for so long as it earns anything at all it has some revenue which ordinarily it would cost something to reproduce, but when a plant ceases to operate, its structural value may be said to die with its going value. As Mr. Williams has well said, they largely live and die together, but the going value is the crowning effort to complete a property, it comes into being last, and in it lies the final test of the value of the physical property.

6. Going value, unlike depreciation, has, where it exists at all, been bought largely if not wholly by cash outlay. It is not an unearned increment or a theoretical accretion from causes outside the ledger of the operating plant, except perhaps in one item, viz., opportunity to earn during duplication. After duplication is completed, going value is paid for in cash outlay to meet fixed charges and operating expenses that are not earned, and which often require expenditure to a greater extent than the going value will be worth in years to come.

7. Any estimate of the cost of the duplication of a given income (going value) is of practical necessity based upon some appreciable length of time in which to operate, recover and duplicate, just as conceptual physical construction is of necessity based upon some reasonable time in which to construct. Such time assumption for a conceptual starting plant to obtain and build up a given income must of necessity be in the future, largely after completion of the conceptual construction, for to reason otherwise would be to introduce estimating methods which are not humanly possible in actual life, and this, as I conceive it, is contrary to the reasonable intention of the theory of reproduction.

NECESSARY DATA FOR GOING VALUE

8. The necessary data and personal requirements for the fair and proper computations of the cost of reduplicating a given income, (going value) are as follows:

(*a*) An accurate statement of normal and proper income of the existing or going plant at some period near to the date of computation in order to know the income which the starting plant must begin to acquire.

(*b*) The past financial history and growth of the going plant and its business in order to determine those future earnings of the going plant to which the starting plant must attain.

(*c*) The normal and proper past operating expenses of the going plant in order to make proper comparison with the probable operating expenses of the starting plant.

(*d*) The separation of the revenues of the going plant in the past into those from public and those from private sources in order that the more prompt probable acquisition of public revenue may be duly allowed for.

(*e*) Data showing the general growth of the community and its salient industrial characteristics in order to confirm forecasts of growth of business in the near future for both starting and going plant.

(*f*) A wide experience on the part of the estimator in the art of constructing and operating plants and supplying communities with water.

(*g*) The ability on the part of the estimator from similar experiences to carefully analyze the practical effects of a conceptual starting plant in any given community, and a comparison of its results through a series of near future years with the probable results of the operation of the existing or going plant through the same period, and here it may be properly said that in no other part of the conceptual process of reproduction is it more important that the estimator be free from all personal bias, and have that intellectual independence which enables him to value fairness above all other considerations.

9. Given the above data and conditions, the cost of the reproduction of the income of any existing or going plant will be the difference between the net results of its operation and the net results of a well-conducted starting plant, through the time necessary to enable the starting plant to be completed and attain an income equal to that of the going plant.

10. As the differences between the actual going plant and the conceptual starting plant are necessarily all in near future years, the present worth should be found in each instance.

In valuing going plants on the theory of reproduction, the addition of going value is sound in principle, but the fixing of the exact amount, resting as the data does upon assumptions in the future, is always difficult of precise determination. This difficulty is wholly attributable to the reproduction method, which requires the assumption of time for construction and duplication, of necessity projected into the future. Of this future the going value element is the farthest removed from the present time of all other items, and therefore the least definite with which to deal.

In spite of these difficulties, competent and experienced appraisers, familiar with the art of constructing and operating water plants, and having wide experience with varying conditions, have usually agreed within quite reasonable limits in computing going value.

WHAT GOING VALUE IS NOT

Having shown what going value is, it may be permissible to show what going value is *not*, as well intentioned efforts have been made by courts, appraisers and engineers, to find some short cut which would be at once easily understood and explained, and simple to compute.

Some of these proposals are as follows:

1. To predicate the cost of going value upon the cost of constructing house services. This idea arises from the theory that going value is the cost of getting the plant connected with the consumer and that the cost of getting it connected to the consumer is practically the cost of the house connection service. Obviously, this does not bear investigation for many reasons, for while the consumer is being connected, the works are being operated at a loss. Interest charges are not being met. Depreciation is beginning and is not recoverable, and in many other ways going value costs are incurred which would not appear in the computation. Moreover, it is certain the mere cost of the house service has little if anything to do with going value. In many works the house services are owned by the company and to reduplicate the works they would necessarily be included in the physical value, and to include them again as part of the going value would be quite illogical.

2. It is usual for courts and appraisers unfamiliar with the theory of going value, to attempt to estimate it as a percentage of the value of the physical property. Estimates of going value which have been made in a logical manner in about two dozen cases, produced results which are found to range all the way from $9\frac{6}{10}$ per cent to 47 per cent of the physical property. Finding this to be the case, a guess percentage of the physical value has been roughly taken as a short cut to the problem.

Now if such percentage were based upon gross revenues rather than upon physical values it might have more justification, but as a percentage of physical values it has no justification beyond the fact that, so far as we have gone, physical plants with general similarity have been followed by a general (very general) similarity of going values. Possibly even this similarity is artificial and personal to appraisers rather than really the case.

The ability of citizens of a community to obtain potable water by other means than through the public supply has, for instance, much more effect upon going value than does the cost of the physical plant. In communities where good wells abound and the soil has good filtration qualities, going value will usually cost much more to acquire than where good water is not obtainable in any alternative manner, and many plants have been failures owing to their inability to acquire sufficient going value at any reasonable cost.

The physical property has, in fact, nothing whatever to do with going value, except it be quite accidentally, that is to say, when plants happen to be similarly situated in those elements that go to make up going value.

3. An effort has been recently made to find the proportion that going value bears to the established revenue which is to be reproduced. Here we approach more reasonably the analogy required, that is, that things derived from like data may be compared in a general way, for going value is to some extent a function of revenues, but yet is in fact only the cost of reproducing a revenue. Building estimators sometimes estimate the cost of a house by its cubic content as compared with other sized houses of known cost, and with only general ideas as to interior finish. In somewhat similarly rough way going value might be deduced from amount of revenues, where plants are so similarly situated *that the conditions of reproducing revenue are alike* or even fairly so. But because plants are similarly situated with respect to amount of income, by no means assures us that they may be similarly situated and with respect to the cost of recovering such income, for while population, growth and manufacturers may be almost precisely alike in two places, yet the character of the water served, its quantity and quality, the availability of other sources, filtration, hardness and many other items may make the cost of recovery of income differ largely so that even proportions based on the comparison of revenue to going value are deceptive and illogical. Of necessity too, such comparisons must be made upon the basis of a large number of computations of proper and logical going values, and it is to be doubted if such computations exist in sufficient number to warrant the comparison as yet.

4. I need hardly to speak of "freak going values"; they are numerous. Perhaps, however, extreme cases may be cited.

One I have seen capitalizes the gross revenues of the plant at 4 per cent and adds it to the physical property along with a liberal franchise value. It is needless to say that here every value is in at least twice, and probably some values are in several times. On the other hand, it has been seriously suggested that if a given plant owning its services were theoretically stripped of its consumers over-night, the plumbing would still exist in all the houses, the people would be educated to the use of water, and the recovery of the income would be made in less than twenty-four hours by the liberal use of the telephone and extra gangs of active men with service cock keys. Could we get these two computations together on one case, obviously the judge in that case would be justified in the rather too usual custom of splitting the difference.

If going value is reasonable at all, it is reasonable because it is logical, and if logical it must be founded on data that are logical. Let us turn for a moment to the further consideration of these data, much of which has been ably discussed in appraisal boards composed of fair-minded men, sincerely anxious to ascertain the reasonable truth.

ESSENTIALS OF PROPER COMPARISON

In comparing a duplicate starting plant with an existing going plant for the purpose of estimating the cost of recovering a given income, the following premises have been pretty generally agreed upon:

1. The estimate must be arrived at by the mental concept of a parallel plant, which step by step is devised, constructed, completed, put into operation and finally acquires all of the revenues of the existing plant in due and proper order.

2. The process of constructing the starting plant and the reduplication of its income must proceed in a manner that is humanly possible through complete and reasonable periods of time.

3. The comparison does not admit of supposed rivalry or competition between the starting plant and the going plant, but, to be just, the business of the going plant is to be considered as extinguished just as fast as the starting plant is ready and able to take it on, or the business may be considered as transferred without prejudice or demur as fast as conditions permit.

4. The cost of reproducing present income and determining going value at the present time is not to be confused with a past going value, for what it *has* cost the going company for its going value in the past has no more to do with the case than the past cost of physical property has to do with its present reproduction cost.

Where going value has been acquired in the past by an operating company, moneys have, invariably, actually been expended for its acquisition. Now that past acquisition of going value will be found to have suffered its appreciations or its depreciations as the case may be, and its present value is not what it has cost, but what it has cost plus its appreciations or minus its depreciations, this result ought theoretically to approximate at least the cost of duplication.

To illustrate this, past going value may have paid largely to educate the people to the value of potable water delivered under pressure. It is held by experienced estimators that this expenditure for education has depreciated because its benefits cannot be retained by any particular company as an asset, but are lost to it individually. Consequently, we must allow that at the present time populations are used to potable water and its increased value under pressure is reasonably and generally known. Going values, therefore, often have cost more in actual expenditure than they are at present worth. A part of this depreciation in going value should be attributed to the general advance in civilization and the general increasing knowledge of the benefits of a water supply.

ACCOUNTS NECESSARILY CONSIDERED

5. In comparing the going value of an existing plant with a conceptual starting plant, there are five important accounts to be compared. They are:

1. Interest on Investment.
2. Depreciation.
3. Operating Expenses.
4. Public Income.
5. Income from the Private Consumers.

Where these accounts happen to balance, as for instance in the case of Interest on Investment after completion of the starting plant, they may be omitted for purposes of simplification.

6. *Interest on Investment* during the period assumed for the construction of the conceptual starting plant produces a balance in favor of the starting plant, and must therefore be considered, but it is usually treated as a part of the physical cost and added to capital account. It might be more logical, however, to include it in going value, in which case it makes the going value total larger and, equally, the physical property total smaller than would otherwise be the case. Present practice, however, inclines to consider it as a capital cost item and exclude it from going value.

7. Depreciation is obviously much less for the starting plant than for the going plant and in proper comparison produces a balance in favor of the starting plant.

8. Operating expenses are generally less for the starting plant than for the going plant. During the period assumed for the construction of the starting plant, the starting plant has no operating expenses, while the going plant has full operation. After the starting plant is completed, operating expenses begin and gradually reach full operation cost during the period assumed for recovery of income to normal. Operating expenses are, however, necessarily greater in the starting plant in proportion to its income, than is the case with the going plant, for the reason that administration, labor, salaries and other accounts are but little reduced by partial operation. Also the first years of operation are always necessarily expensive owing to lack of correct organization, adjustments of new construction and the merging of construction into operation.

The balance of comparison of operating expenses between the going and the starting plant is usually a credit to the starting plant in its net results.

9. *Public Income* or hydrant rentals will necessarily be a credit in full to the going plant during the assumed period the starting plant is under construction. After the completion of the starting plant it is usually assumed that this business may be and is transformed at once to the starting plant, and thereafter credited to it. Exceptions to this rule may be made in the case of very large plants taking considerable time to construct, for in such cases portions of the public revenue may be transferred at different intervals as the starting plant is able to care for them, and transferred perhaps, even prior to the full completion of construction in some cases.

10. *Private Income* or returns from the domestic consumption will necessarily be fully credited to the going plant during the period assumed for the construction of the starting plant, but after the staring plant is ready to operate, it begins to recover or absorb the income from domestic consumption as fast as people can be persuaded to connect with the plant, so that in an assumed number of years all of the domestic consumption is finally acquired, thus completing the duplication of the revenue.

In case of large plants taking some years to construct, it may be sometimes the case that water is served to limited districts before the plant as a whole is complete, and this not only may be allowed for, but there are cases where temporary pumping plants might be warranted so that the acquisition of business may be hastened. The cost of such temporary pumping plant should, however, be added to the operating expenses of the starting plant and are a drawback, only occasionally warranted.

The net credit then of the domestic revenues will be to the going plant during all of the period assumed both for construction of the starting plant and for the production of its revenue up to the final assumed year in the future when the income of the going plant is assumed to be equaled by the starting plant.

11. The period assumed for construction of the starting plant can be pretty definitely fixed from experience in similar construction and is the greatest factor in going value, involving, as it does, the inability of the starting plant to earn during that time.

RECOVERY OF REVENUE

12. The period assumed for the recovery of revenue by the starting plant after completion must be predicated upon:

(*a*) The ability of the population to obtain good water elsewhere, especially in small cities and towns.

(*b*) The incentive of the consumer in the large town by reason of his confined situation.

(*c*) The physical possibility of connecting and plumbing large populations.

(*d*) The number of large consumers that could be quickly transferred, such as manufacturers, railways and the like.

(*e*) The number of small consumers that would be only sluggishly acquired.

(*f*) The progressiveness and wealthiness of some communities *vs.* the poverty and ignorance of others.

(*g*) The incentive of the water company to begin paying its fixed charges.

The net result of all these influences in the opinion of most estimators will be to make rapid growth in the first interval of time succeeding completion followed by slower and slower acquisition until the final completion. In the first year the limiting conditions in most communities will in all probability be the physical impossibility of making all connections acquiring business, and, on the part of the taker, of doing the necessary plumbing. While the limiting conditions in the last year will be probably the sluggishness of the outlying and small consumer due either to his ability to obtain good water elsewhere, or his indifference, financial inability, or both.

The effect of the assumption of time period for the recovery of revenues is less than half as great as the assumption of time period in construction, for the reason that with public revenues promptly acquired by the starting plant on completion of its construction and the subsequent rapid acquisition of large consumers, the latter years of this period are ineffective in producing much credit to the going plant.

13. The periods usually assumed in plants costing less than $1,000,000 are for construction from one to three years and for acquisition of revenues from three to five years additional.

14. It is not assumed by experienced estimators that population are provided with plumbing and all appurtenances for utilizing water under pressure. Only general knowledge of the value of good water under pressure is conceded. Upon this point, however, there are differences of opinion.

It must be conceded, however, that if we are to proceed on the theory of reproduction, in carefully reproducing the conceptual starting plant, we cannot humanly expect to find, on its completion, consumers awaiting it with plumbing which can not have been reproduced under reasonably probable conditions.

Fairness will here naturally lead us to consider what would happen in a natural and humanly possible way, and in such case plumbing in house would naturally and inevitably await the certainty of water connection before it would have the incentive to exist.

15. In all computations assuming future credits, it is conceded by experienced estimators that they should be reduced to their present worth at going rates of discount.

DIAGRAMMATIC REPRESENTATION

To those who are accustomed to thinking by the aid of diagrams, the subject of going value may perhaps be made more clear by the one here shown depicting the typical growth in value of a water works plant, and the time element involved in reproducing the same. This diagram is not illustrative of any particular plant, but is rather a composite of many plants which have come under the writer's notice.

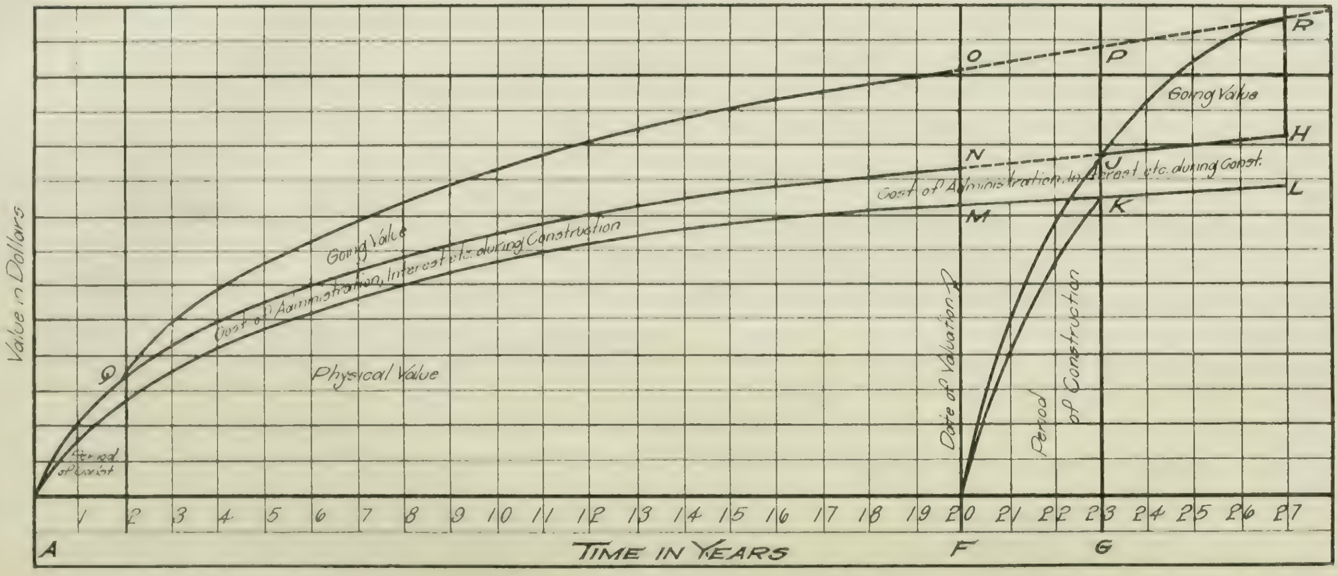
The spaces along the bottom of the diagram give the time in years which have elapsed since the original construction, and it is assumed that about the twentieth year it is desired to value the property for purposes of purchase or fixing rates.

The vertical spaces upon the diagram represent increments of value due to the cost of its construction and its going value. In the beginning of its history two years are assumed to have been necessary for construction, after which time the plant begins to acquire its going value. In the earlier years of operation the acquisition of going value is necessarily quite slow. An additional curve of growth shows, roughly, the proportionate costs of administration, interest, etc., during construction, which are added to and are a part of the physical value.

For purposes of illustration, it is assumed that in its twentieth year this plant is to be valued. The estimator thereupon proceeds to compute the construction of a conceptual duplicate plant and, as the original plant has grown in value year by year through minor additions and extensions, he is now facing the contingency that it will require perhaps three years instead of two for the actual physical replacement. This, as shown by the area *F.K.G.*, is in advance of the date of the estimate, as must be the case if the estimator is limiting himself to what is humanly possible.

During the construction the estimator computes the necessary expenses for administration, cost of interest on capital being invested, engineering expenses, etc., which may be graphically represented as added to the other construction by the area *F.J.K.*,

Diagram
SHOWING TYPICAL GROWTH IN VALUE OF WATER WORKS PLANTS
and
METHOD OF REPRODUCING SAME
at
Some Fixed Date



JOHN W. ALVORD, C.E.
Chicago.

reproducing at the end of the proper assumed construction period the value of such items as they already exist in the going plant.

The estimator then arrives at the value *G.J.* for the physical property, and it remains for him to reproduce the going value *O.M.*, existing at the date of his valuation, but in order to recover this going value we must again be cautious enough to proceed in a manner which is humanly possible, that is to say, the conceptual plant will not only have to recover this cost of reproducing the income, but at the same time, it will be hampered by the necessity in common with the going plant of recovering such growth of revenue as the near future may reasonably yield. This, of course, is not an element of its credit except as it embarrasses and delays it in acquiring the full going value *O.M.*

If the estimator further proceeds in a manner which is humanly possible, he must consider this acquisition of going value as taking place in the period following the periods of construction, which period is assumed for illustrative purposes in this case to be four years, and after having made the assumption and computations for credits to the going plant must of necessity refer them back to their present worth. This reduces his values back to the twentieth year, and completes his valuation of *F.O.* upon the diagram.

This total is a "total value" diagram and must not be confused with a "revenue diagram" which is frequently used in somewhat the same manner. In computing the cost of reproduction of revenues or going value, examples of such revenue diagrams are shown as an appendix to this paper. These are actual selected cases of going value which have been computed by boards of appraisers at different places and by different methods. As it is desirable to include among them some properties in which transfer was not accomplished, it has been thought desirable not to give the names of the plants so that the list might be as complete as possible. It will be seen that they are not always computed on the same basis. This is accounted for by the fact that some of them were of an early date when the theory of going value was not, perhaps, as fully understood as it is today, or in some cases they have been computed by boards among whom were estimators not fully familiar with this subject.

The following notes on these diagrams may be of interest:

No. 1. In this case there has been allowed a period of construction and rather long period of recovery. This was because the city was backward in growth. It will be noticed, however, how little the last few years of recovery add to the total value.

No. 2. Allows no period of construction, the city exercising an option of purchase. The period of recovery here is rapid in early part of the curve, due to large manufacturing interests, and sluggish toward the end, due to population of small financial capacity.

No. 6. Is a fairly live town in which the option of purchase was being exercised. There is therefore no construction period included and the recovery is fairly rapid. One large institution taking considerable water is the reason for the large proportion of revenues acquired the first year.

No. 7. Is an exercise of option, but long recovery, although reasonably rapid except at the latter end. A combination of local reasons, too long to be fully described here, but carefully discussed by the board, produced this result.

No. 8. Was a rate case with insufficient financial data prior to valuation to make a really competent determination of future revenue. This was a sluggish town with other opportunities for individual water supply, producing, in the judgment of the estimators, a slow probable recovery.

No. 10. A town without manufacturers and opportunity for individual water supplies. Recovery therefore slow. Past growth also small. One year for construction included.

No. 11. An interesting case of actual competition of two rival plants: one a municipal and one a private plant in the same territory. Later data than that plotted is said to show that the earnings of the new municipal plant fell off while the earnings of the private plant slightly increased, but the figures have not been obtained. This is a most interesting instance of the disaster of actual rivalry in the water works business, as neither plant was able to pay fixed charges and the municipality was finally obliged to purchase the private plant to remove competition.

No. 14. Was a Mississippi River town of rather slow recent growth, but with some manufacturers and large takers. Construction period included as transfer was not optioned. Recovery of income rapid in first three years, but a small increment of sluggish business allowed for. The long period of recovery was due to size of city and its future outlook.

No. 17. A rate case in which estimators predicated going value on fair return only, raising some interesting questions as to course which they might have pursued if revenues were below a fair return.

No. 19. A large manufacturing city with large takers. Construction period included, but local opportunity for temporary pumping plant in service prior to full completion allowed for.

INCLUSION OF PERIOD OF CONSTRUCTION

Some difference of opinion has arisen between estimators as to whether the period of construction of the starting plant should be considered in going value. This period, of course, involves the losses in revenue which the starting plant is obliged to confront, because it is unable to take upon itself the responsibility of delivering water until its physical completion. Some estimators and even one court have held that this period was not a part of going value because it did not cause money to be necessarily expended by the starting plant. They point to the fact that the original plant did not receive revenues while it was being constructed, and that if we allow interest upon the capital invested during construction to be added to the capital account we have remunerated the projectors sufficiently.

This conclusion may satisfy the conscience of the hasty investigator, but it does not meet the whole logic of the situation, as becomes apparent when we apply the test again (as we have so often done before in this paper) as to what is "*humanly possible*," and at the risk of repetition we repeat the argument against this view.

Granted that there is a going plant, and that the estimator stands at the point where he is under the necessity of making his conceptual plant fully equal to that going plant in value, can he properly ignore the fact that he must undergo a period of construction in which no revenues will be earned by the starting plant, as is done by the going plant? If he ignores this fact and assumes the starting plant to be immediately possessed of such revenues, he has rubbed an Aladdin's lamp again.

Or to illustrate this more clearly, take the case of a city contemplating the possible purchase of a Public Utility Company's works, or the alternative of building a duplicate plant of its own. Any estimates it may make for building a duplicate plant that neglected to remember that its duplicate plant would not commence acquiring revenue until after completion would unfairly represent the situation, for the city obviously would want to purchase the going plant at such price if it could, because it would at once jump into possession of its revenues, when to build one of its own (without considering at all competition) would necessitate only beginning to earn after construction was finished.

It is therefore quite certain that there is an element of going value accruing to a going plant by reason of the fact that it cannot be created instantaneously by the mere "rubbing of an Aladdin's lamp," and that usually some years of construction must necessarily elapse before revenue could be even begun to be acquired by a rival of any kind.

CONSERVATIVE ESTIMATING

It is perhaps necessary to point out that estimates of going value are very easily overworked, and that the worth of the going value liberally taken necessarily extracts in favor of the going plant all of its possible operating credits in an indeterminate future. Some allowance, therefore, should certainly be made for the uncertainty of these future assumptions. This must evidently be done by a strictly conservative estimate of going value, assuming data upon the best possible practical conditions which the starting plant may hope to meet with in the case in hand in acquiring and reproducing the income. A recovery of income by the starting plant should be assumed which is all that can be properly expected, and its time of idleness in construction should be limited whenever properly possible. All of the incentives to the starting plant to early and quickly acquire its business and pay its fixed charges and accumulate its fair return should be considered. When this view of the situation is taken, going values may be produced which will look reasonable to the estimator from both sides of the valuation, and he should satisfy his conscience in this way no matter which side he happens to be engaged upon.

Year	OLD WORKS
	Domestic Earnings
1907	21800
1908	22720
1909	23640
1910	24560
1911	25480
1912	26400

Population 11269
Number of miles Wa

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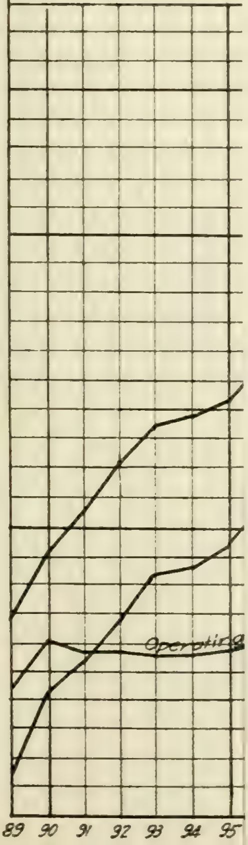


①

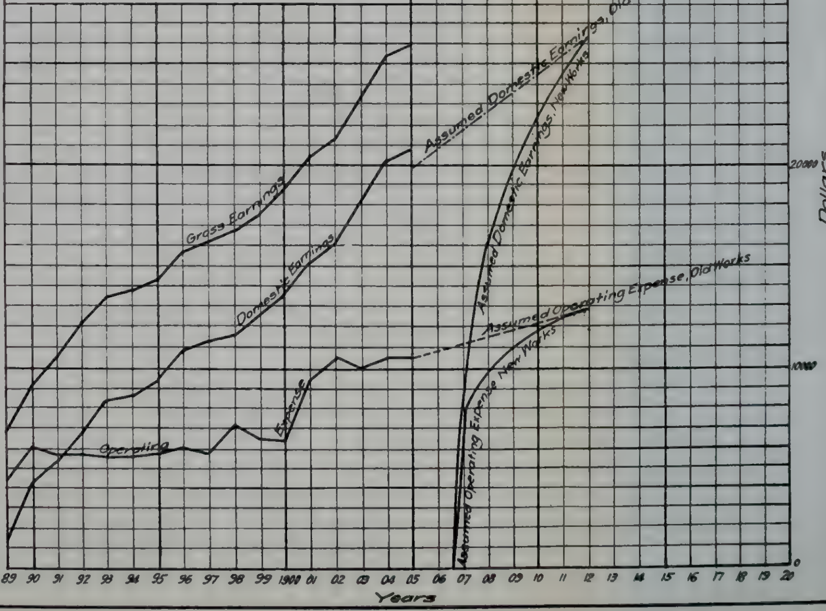
Year	OLD WORKS	NEW WORKS			Annual Going Value.	Factor	Present Worth Going Value
	Domestic Earnings	Domestic Earnings	Difference Op. Ex.	Total Credits			
1907	21 800	8500	3500	12 000	9800	.952	9340
1908	22 720	16000	1500	17 500	5220	.907	4740
1909	23640	19500	800	20300	3340	.864	2870
1910	24 560	22500	400	22900	1660	.823	1380
1911	25480	24800		24800	680	.784	530
1912	26400	26400		26400	0		0

Population 11269
Number of miles Water Mains 8½

Total Going Value $18860

TABLE AND DIAGRAM
Showing Estimated
GOING VALUE

To Accompany Report of
JOHN W ALVORD
Hydraulic & Sanitary Engr.
1207 Hartford Bldg
CHICAGO



THE OPTION OF THE CITY

It has been suggested by the writer that certain modifications may be made in going value, due to the fact that in many franchises, in the West at least, the municipality often holds an option, or right to purchase plants at an appraised valuation at given intervals of time during the life of the franchise. Such option necessarily is of value to the city holding it. The city has, by contractual relations, acquired the right to become possessed of the particular plant in question. Under these circumstances, it must be conceded that it does not have to face the possibility of building a duplicate or rival plant; that by its contractual relations it has acquired the right at once to step into possession of the plant and its revenues which it has authorized and legalized.

Under such circumstances, it is a question whether the value of this option should not be recognized in some way. The writer's idea has been to recognize it in such cases, and, under such rights, by leaving out of the computation of going value the increment of earnings which the going plant derives while the conceptual starting plant is under construction. This considerably reduces going value under such circumstances; whether this reduction in revenue is precisely the value of the option which the city holds or not is subject for discussion, but it seems to the writer that it does and is entirely logical. One or two estimators to whom he has proposed it have dissented. It is offered here for what it is worth as a matter for future consideration. In any event, it is an attempt to recognize in some way the optional values of such contracts as give the right to purchase at fixed intervals during the life of the franchise.

Table Showing

DATA OF VALUATIONS OF WATER WORKS PROPERTIES

(Located Largely in the Miss. Valley)

Showing

Lack of Relation of Going Value to Physical Property, Gross Income and Service Connections

Ref No.	Population	Water Mains Mi.	Service No.	Value Reproduction of Physical Prop'ty	Total Depreciation	Net Value Physical Prop'ty	Domestic Revenue	Hyd Rentals	Gross Revenue	Going Value	Going Value per Cap	Going Value per Service	% Going Value to the Phy Prop	% Going Value to Gross Revenue
1	11269	8½	600	95280	24010	71270	21800	4200	26000	18860	167	31.40	26.5	72.5
2	25802	40	3015	710760	73000	637760	72000	23000	95000	68614	2.66	21.80	10.8	72.3
3	35200	60	6000	1384700	178000	1206700	123000	24000	147000	243430	6.90	40.60	20.1	165.0
4	42000	63	3300	432874	48489	384385	38000	17000	55000	62718	169	19.00	16.3	268.0
5	14450	28¼	1922	235336	22336	213000	16900	11100	28000	41500	287	21.60	19.5	148.2
6	6070	11	500	103800	25940	77860	11600	3300	14900	8961	1.48	17.90	11.5	60.3
7	2215	13	225	92540	13230	79310	9100	3400	12500	17800	8.04	79.10	22.4	142.0
8	6400	10¼	350	115060	8400	106660	13340	1836	15176	10274	1.61	29.30	9.6	67.8
9	4100	9	166	89800	9500	80300	8700	3750	12450	12830	3.12	7740	16.0	103.0
10	3060	9	400	92520	14970	77550	12400	8000	20400	23862	7.84	59.60	30.5	116.0
11	38469	45	6217	686100	59800	626300	17000	2000	19000	(None		Allowed)		
12	155540	229.2	16491	6441117	740333	5697784	387961	117936	505897	562512	3.62	34.10	9.9	111.0
13	8400	14	1400	182720	32100	150630	18500	5500	24000	32616	3.88	23.30	21.7	136.0
14	36252	48	4040	564027	115019	449008	64700	11800	76500	149823	4.13	37.00	33.3	196.0
15	22962	30	2500	495026	38948	396078	34100	7368	41468	136922	5.96	54.80	34.6	330.5
16	6280	18	1029	90179	33367	56812	14700	6400	21100	26710	4.25	26.00	47.0	126.5
17	12120	27.4	1018	523500	29640	493860	55500	4960	60460	52008	4.92	51.00	10.5	86.0
18	62000	93.8	9040	2437000	198750	188250	147800	44340	192140	324000	5.23	35.80	16.3	168.0
[illegible]	83700	130	11000	1736392	137001	1599391	185048	45299	230347	187976	2.25	17.10	11.8	80.5
20	34350	93.6	9183	1321100	156573	1164540	150000	12000	162000	180105	5.25	19.60	15.5	111.0

Maximum Value 8.04 79.10 47.0 330.5
Minimum Value 1.48 17.10 9.6 60.5

NOTE:— In order to include some examples of Going Value where information is confidential all names of places have been omitted

JOHN W. ALVORD, C.E.
Chicago.

ERRATA.

Page 206. Under column, "Value Reproduction of Physical Property," third line from bottom, read "2.103,000" instead of "2.437,000." Column "Net Value Physical Property," third line from bottom, read "1,904,250" instead of "188,250."

Page 207. Under "Old Works," "Total" column, first line of figures, read "14,270" instead of "10,270."

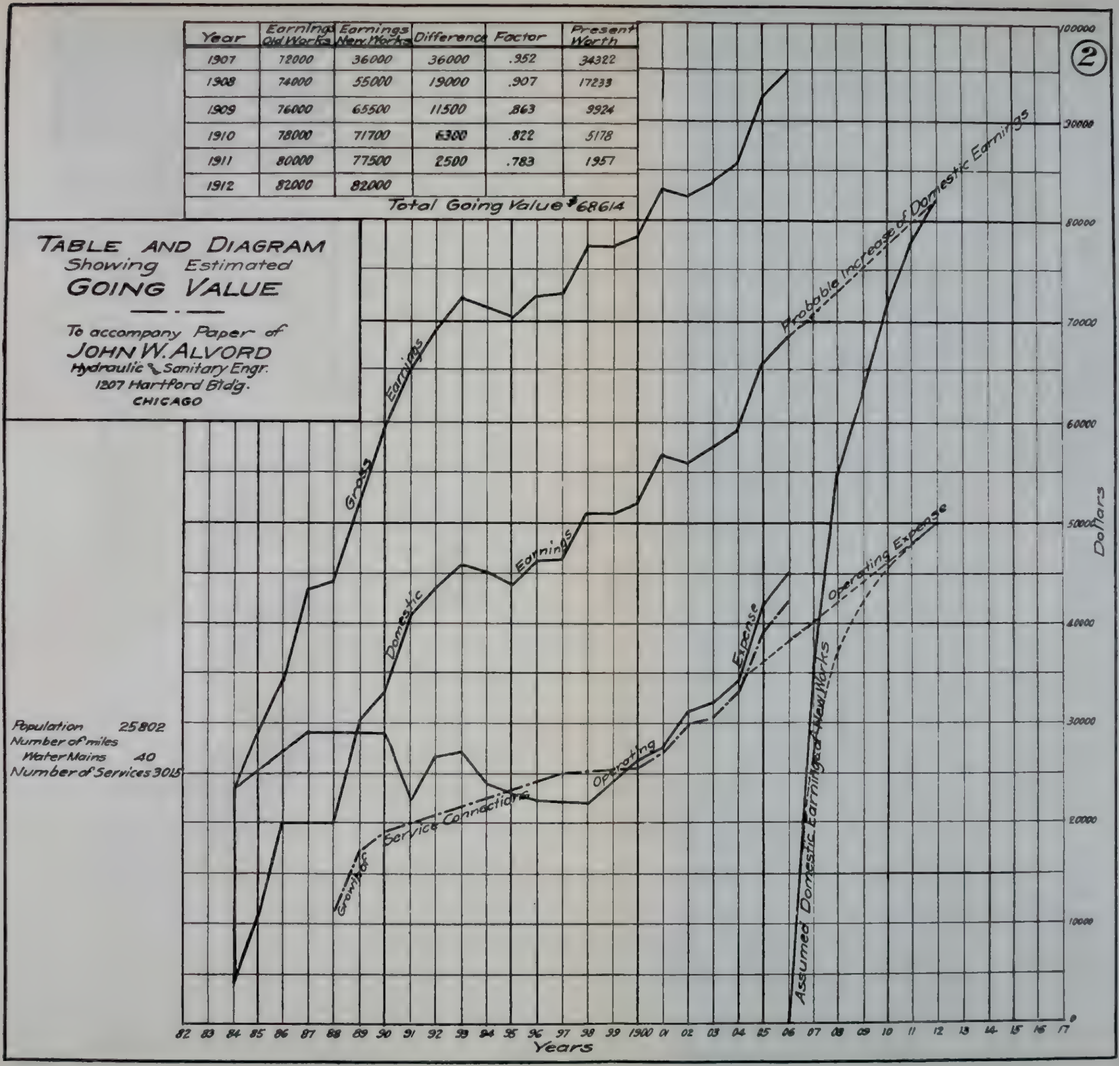
②

TABLE AND DIAGRAM
Showing Estimated
GOING VALUE

To accompany Paper of
JOHN W. ALVORD
Hydraulic & Sanitary Engr.
1207 Hartford Bldg.
CHICAGO

Year	Earnings Old Works	Earnings New Works	Difference	Factor	Present Worth
1907	72000	36000	36000	.952	34322
1908	74000	55000	19000	.907	17233
1909	76000	65500	11500	.863	9924
1910	78000	71700	6300	.822	5178
1911	80000	77500	2500	.783	1957
1912	82000	82000			
				Total Going Value	$68614

Population 25802
Number of miles Water Mains 40
Number of Services 3015



YEAR	Earning Old Works	Earnings New Works	Difference	Factor	Present Worth
1908	11916	5958	5818	.952	5540
1909	12256	9735	2349	.907	2130
1910	12596	11451	1016	.864	877
1911	12936	12342	503	.823	414
1912	13276	13276	0		
		Total Going Value 8961			

Population 6072
Number of miles Water Mains 11
Number of Services 500

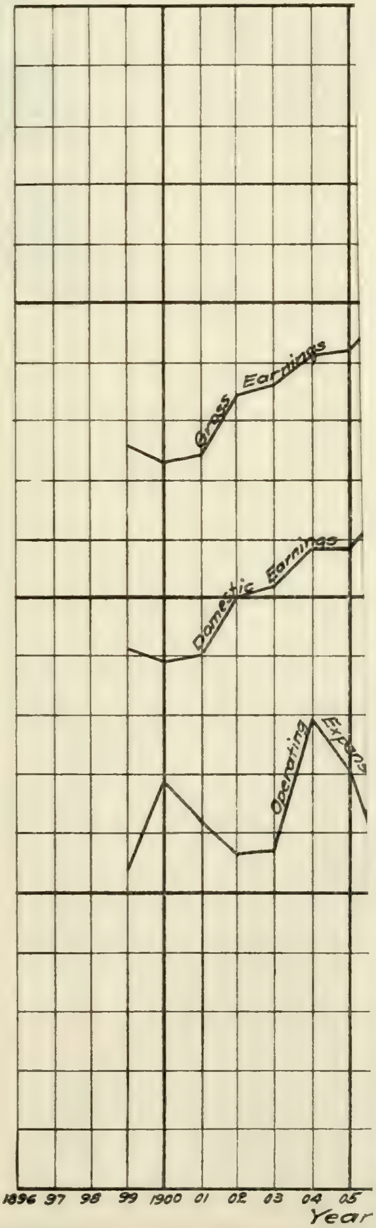


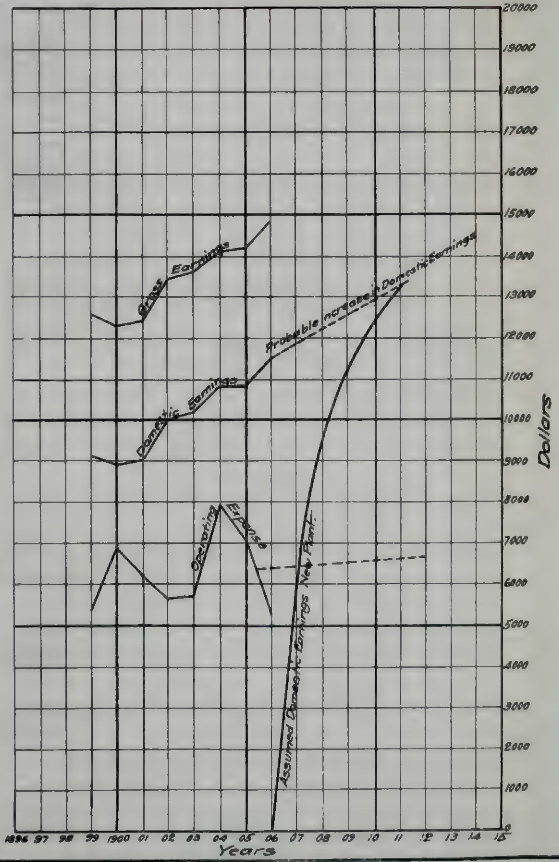
TABLE AND DIAGRAM ⑥

Showing Estimated
GOING VALUE

To Accompany Paper of
JOHN W. ALVORD
Hydraulic & Sanitary Engr
1207 Hartford Bldg
CHICAGO

YEAR	Earning Old Works	Earnings New Works	Difference	Factor	Present Worth
1908	11916	5958	5818	.952	5540
1909	12256	9735	2349	.907	2130
1910	12596	11451	1016	.864	877
1911	12936	12342	503	.823	414
1912	13276	13276	0		
				Total Going Value	8961

Population 6072
Number of miles Water Mains 11
Number of Services 500



YEAR	OLD WOR	
	Earnings	Hydrant Rental
1907	$13340	$1836
1908	13940	918
1909	14540	
1910	15140	
1911	15740	
1912	16340	
1913	16940	
1914	17540	
1915	18140	

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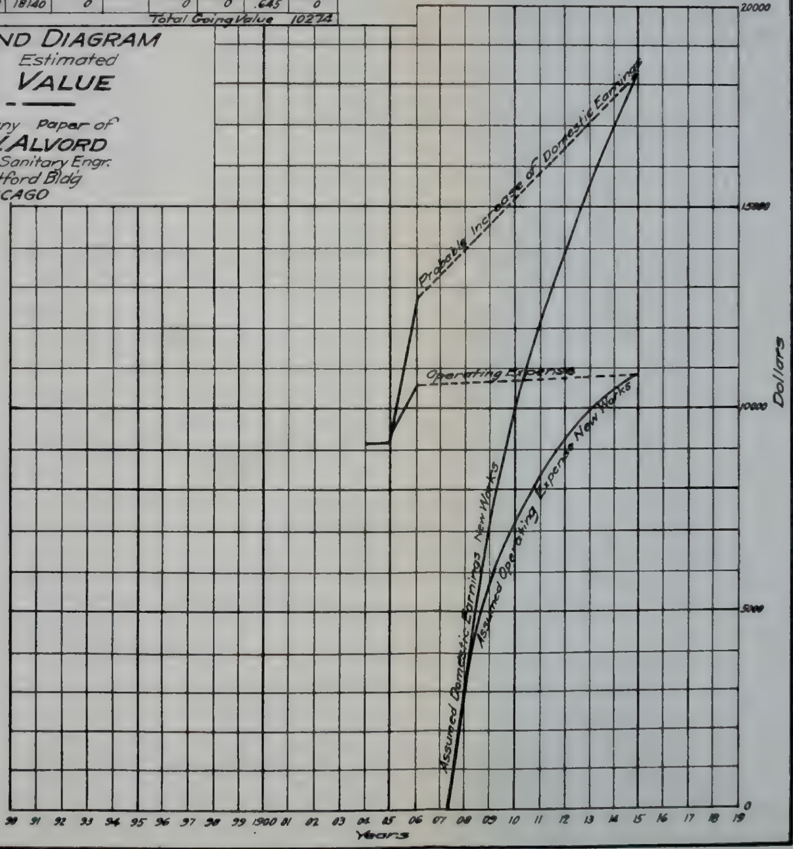
YEAR	OLD WORKS			NEW WORKS.				Difference	Factor	Present Worth Going Value
	Earnings	Hydrant Rental	Total	Earnings	Operation Expense	Interest 4%	Total			
1907	$13340	$1836	$15176	0	$10740	$3750	$14490	$686	.952	653
1908	13940	918	14858	$3000	7740	370	11110	3748	.907	3400
1909	14540		14540	7000	4740		11740	2800	.864	2420
1910	15140		15140	10000	3540		13540	1600	.823	1315
1911	15740		15740	12000	2190		14190	1550	.784	1215
1912	16340		16340	14000	1340		15340	1000	.746	746
1913	16940		16940	15500	890		16390	550	.710	390
1914	17540		17540	17000	340		17340	200	.677	135
1915	18140		18140	18140	0		0	0	.645	0
							Total Going Value			10274

TABLE AND DIAGRAM
Showing Estimated
GOING VALUE

To accompany Paper of
JOHN W. ALVORD
Hydraulic & Sanitary Engr.
1207 Hartford Bldg
CHICAGO

Population 6400
Number of miles Water Mains 10¼
Number of Services 350



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Population 3048
Number of miles Water Mains 9
Number of Services 400

Years	OLD WORKS			Dor
	Domestic Earnings	Hydrant Rental	Total Credits	Ear
1902	$12000	$ 7911	$ 19911	
1903	12200		12200	$ 3
1904	12400		12400	6
1905	12600		12600	8
1906	12700		12700	9
1907	12800		12800	1
1908	12900		12900	11
1909	13000		13000	12
1910	13000		13000	13

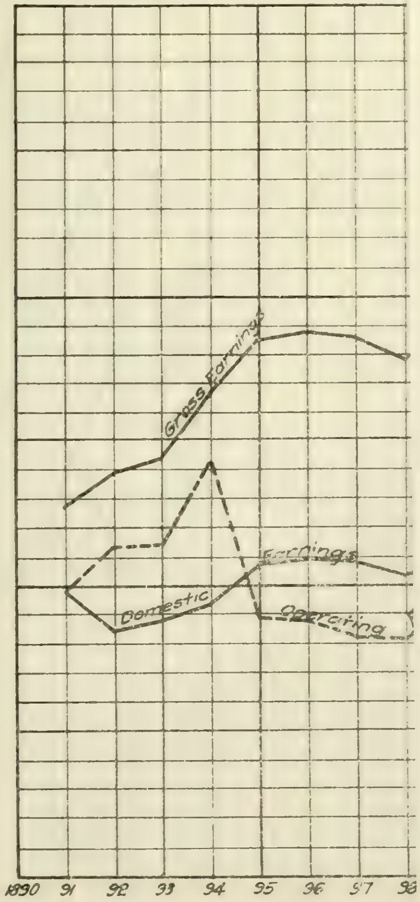

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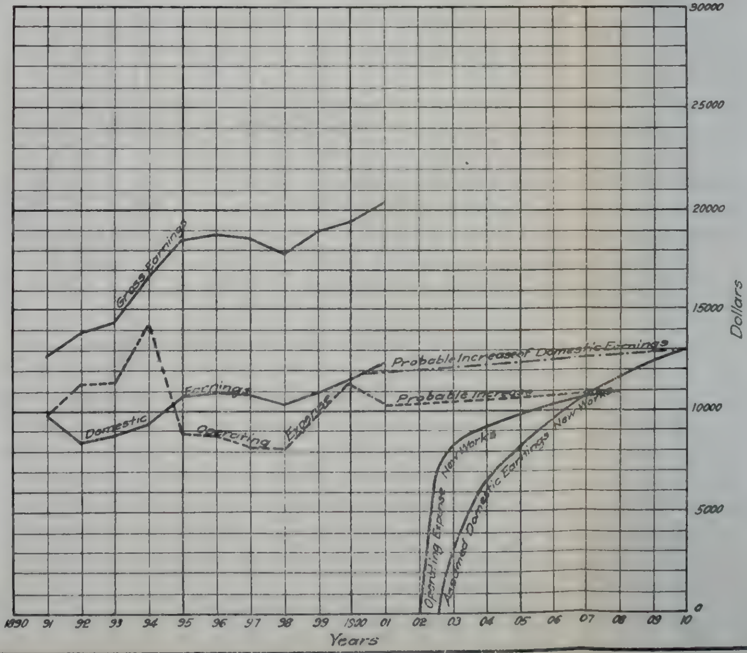
TABLE AND DIAGRAM
Showing Estimated
GOING VALUE

To Accompany Paper of
JOHN W. ALVORD.
Hydraulic & Sanitary Engr
1207 Hartford Bldg
CHICAGO

Population 3048
Number of miles Water Mains 9
Number of Services 400

Years	OLD WORKS			NEW WORKS				Annual Going Value	Factor	Present Worth
	Domestic Earnings	Hydrant Rental	Total Credits	Domestic Earnings	Diff in Operation	Diff in Interest	Total Debits			
1902	$12000	$7911	$19911		$10000	$4800	$14800	$5111	952	$4867
1903	12200		12200	$3000	2000		5000	7200	.907	6545
1904	12400		12400	6500	1500		8000	4400	.864	3826
1905	12600		12600	8000	1000		9000	3600	.823	3000
1906	12700		12700	9250	500		9750	2950	.784	2360
1907	12800		12800	10500	100		10600	2200	.746	1690
1908	12900		12900	11500			11500	1400	.710	1037
1909	13000		13000	12250			12250	750	.677	535
1910	13000		13000	13000			Total Going Value			$23862



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Showing Effect
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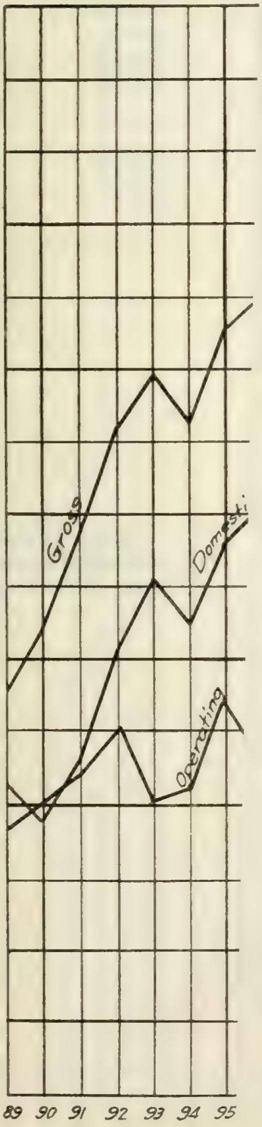
To Accompany Pape
JOHN W. ALVORI
Sanitary & Hydraulic E
1207 Hartford Bldg
CHICAGO

Population 38469
Number of miles Water Ma
Number of Services 6217



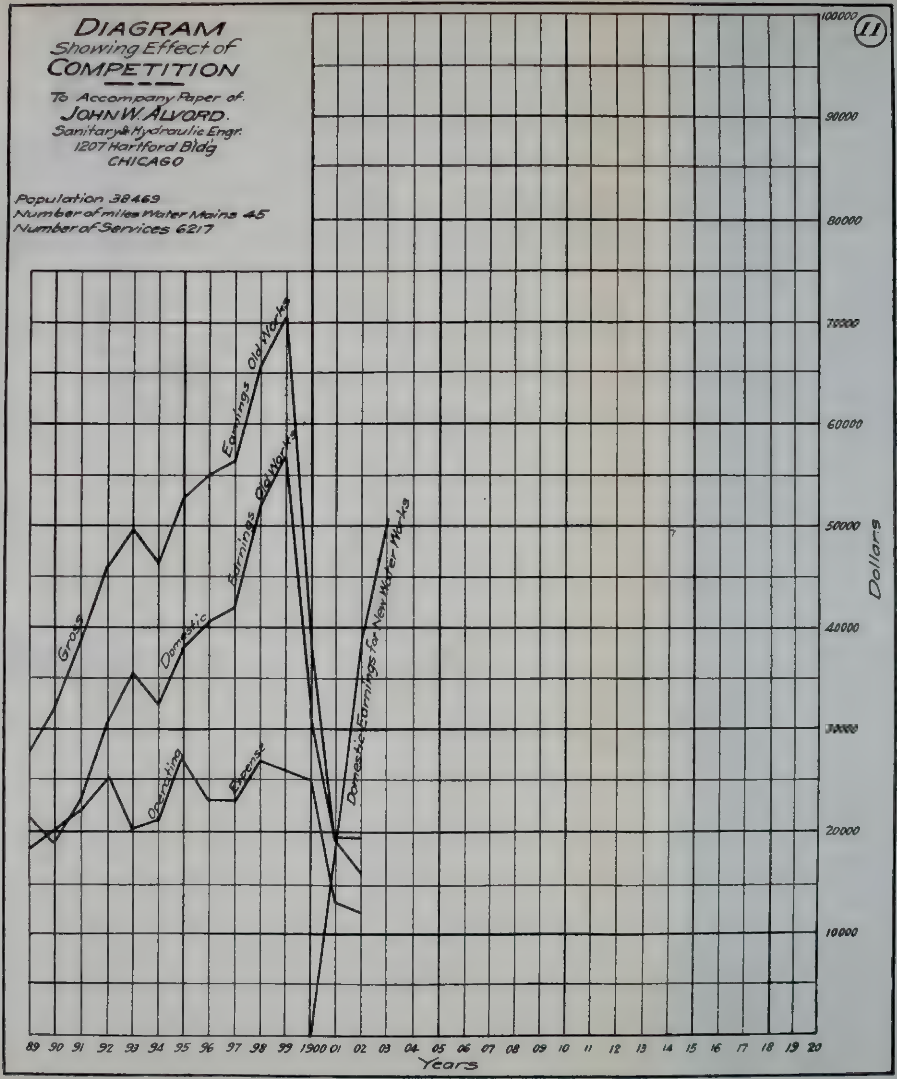


DIAGRAM
Showing Effect of
COMPETITION

To Accompany Paper of.
JOHN W. ALVORD.
Sanitary & Hydraulic Engr.
1207 Hartford Bld'g
CHICAGO

Population 38469
Number of miles Water Mains 45
Number of Services 6217

	Old W	
Year	Domestic Earnings	Operation
1904	76 500	33 000
1905	78 500	34 400
1906	81 250	35 700
1907	83 600	37 000
1908	86 000	38 400
1909	88 300	39 800
1910	90 700	41 100
1911	93 100	42 500
1912	95 000	43 800
1913	97 800	45 200
1914	100 000	46 500

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Population 36252
Number of miles Wate
Number of Services

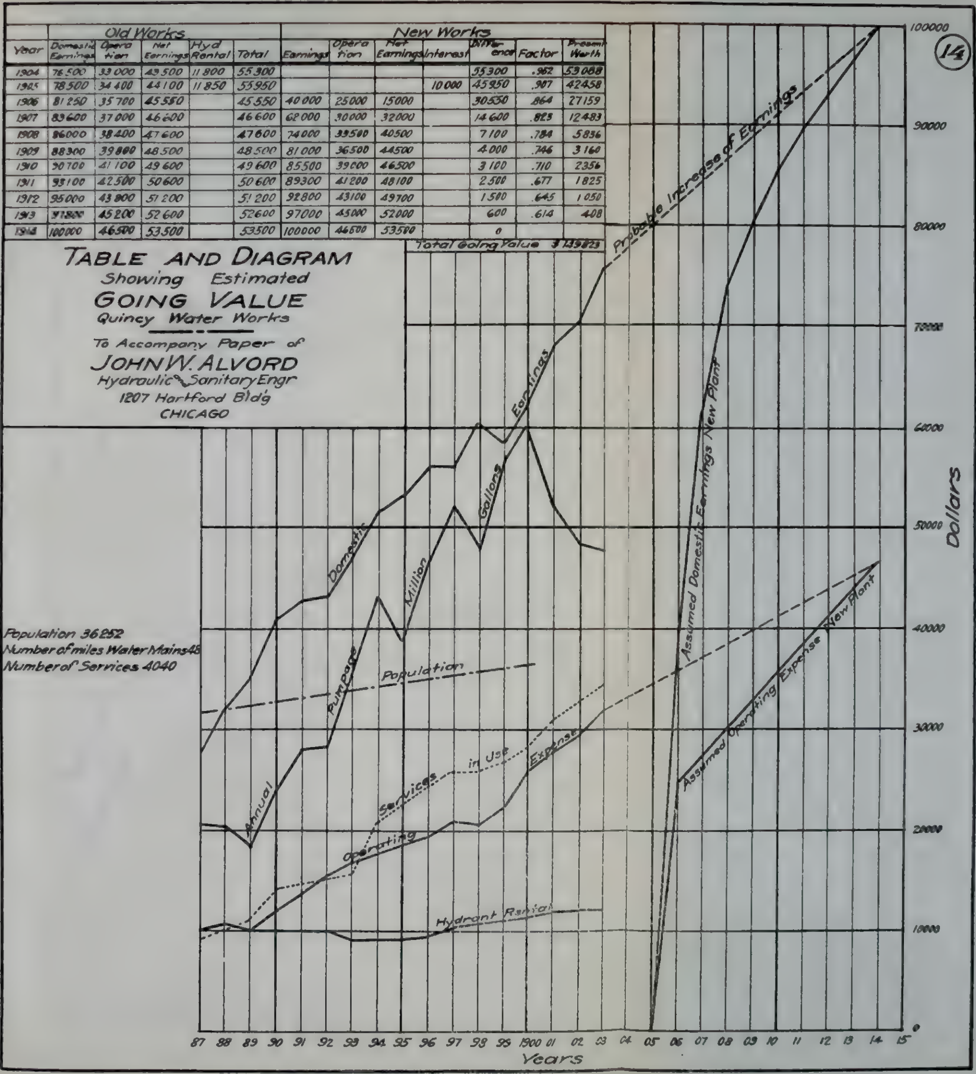
	Old Works					New Works						
Year	Domestic Earnings	Operation	Net Earnings	Hyd Rental	Total	Earnings	Operation	Net Earnings	Interest	Difference	Factor	Present Worth
1904	76 500	33 000	43 500	11 800	55 300					55300	.962	53 088
1905	78 500	34 400	44 100	11 850	55950				10 000	45950	.907	42458
1906	81 250	35 700	45 550		45 550	40 000	25000	15000		30550	.864	27159
1907	83 600	37 000	46 600		46 600	62 000	30000	32000		14 600	.823	12483
1908	86000	38 400	47 600		47600	74000	33500	40500		7 100	.784	5836
1909	88300	39 800	48 500		48 500	81 000	36500	44500		4 000	.746	3 160
1910	90 700	41 100	49 600		49 600	85500	39000	46500		3 100	.710	2356
1911	93100	42 500	50 600		50 600	89300	41 200	48 100		2 500	.677	1 825
1912	95 000	43 800	51 200		51 200	92800	43100	49700		1 500	.645	1 050
1913	97800	45 200	52 600		52600	97000	45000	52000		600	.614	408
1914	100000	46500	53 500		53500	100000	46500	53500		0		

Total Going Value $149823

TABLE AND DIAGRAM
Showing Estimated
GOING VALUE
Quincy Water Works

To Accompany Paper of
JOHN W. ALVORD
Hydraulic & Sanitary Engr
1207 Hartford Bld'g
CHICAGO

Population 36252
Number of miles Water Mains 48
Number of Services 4040

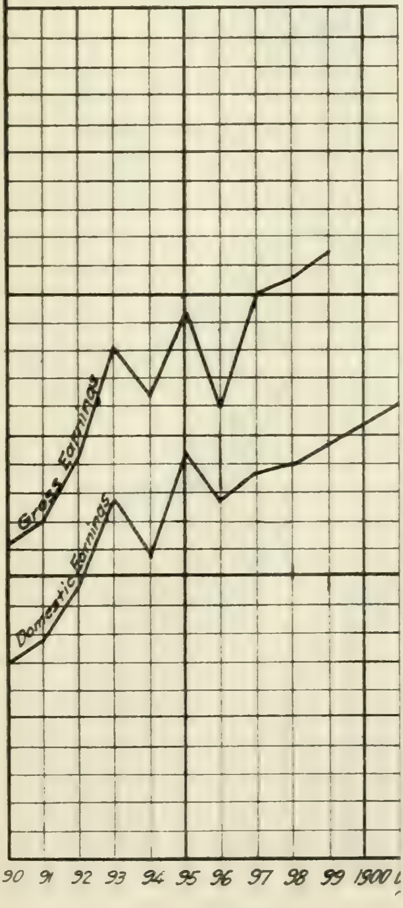


Year	Old Works			Dom Earn
	Domestic Earnings	Hydrant Rental	Total	
1903	14 700	6400	21 100	
1904	15 400		15 400	10
1905	16 200		16 200	13
1906	17 000		17 000	15
1907	17 800		17 800	17
1308	18 600		18 600	18

Population 6280
Number of miles Water Mains 18
Number of Services 1029.

TABLE AND DIAG
Showing Estimate
GOING VALUE
Valparaiso Water Works

To Accompany Report of
JOHN W. ALVORD
Hydraulic & Sanitary Eng
1207 Hartford Bldg
CHICAGO



Year	Old Works			New Works			Annual Going Value	Factor	Present Worth.
	Domestic Earnings	Hydrant Rental	Total	Domestic Earnings	Diff. in Operation	Total.			
1903	14 700	6400	21 100		2100	2100	19000	.952	18100
1904	15400		15400	10200		10200	5200	.907	4700
1905	16 200		16200	13 500		13500	2700	.864	2340
1906	17 000		17000	15 600		15600	1400	.823	1170
1907	17800		17800	17 300		17300	500	.784	400
1908	18 600		18600	18 600		18600	0	..	″

Population 6280
Number of miles Water Mains 18
Number of Services 1029.

Total Going Value $26710

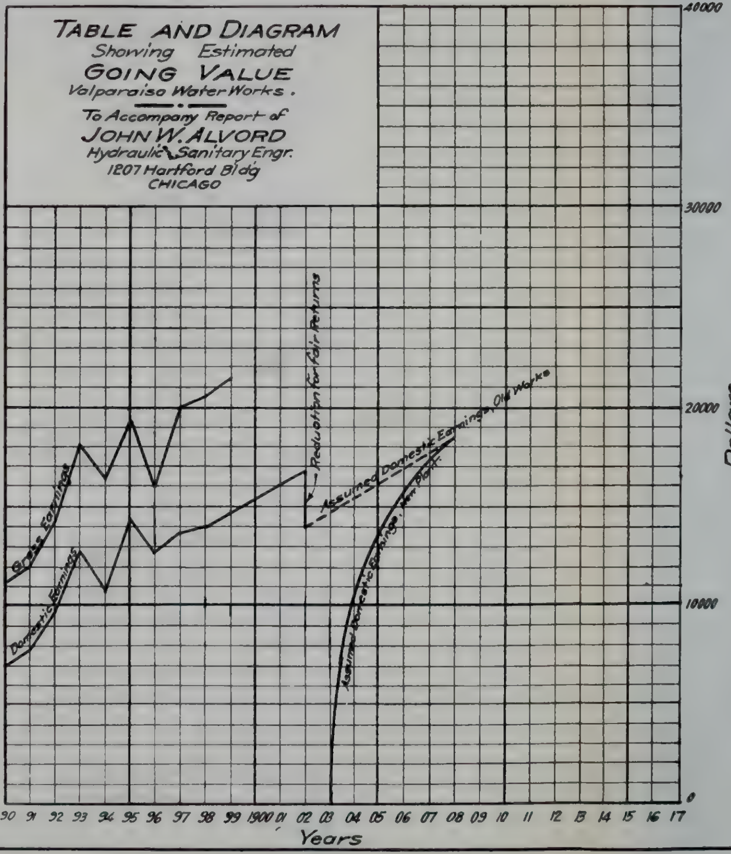


TABLE AND DIAGRAM
Showing Estimated
GOING VALUE
Valparaiso Water Works.

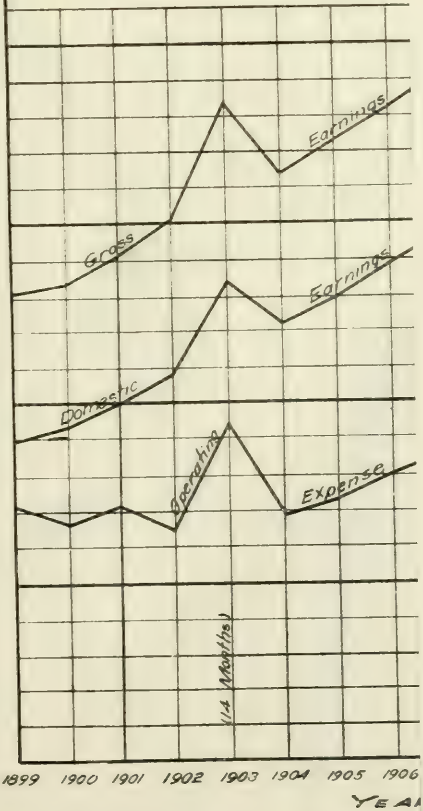
To Accompany Report of
JOHN W. ALVORD
Hydraulic & Sanitary Engr.
1207 Hartford Bldg
CHICAGO

YEAR	Est. Future Gross Earnings of the Going Plant	The Same less Hyd. Rentals taken over by New Plant	Est. Growth of Gross Revenue of a Starting Plant	Est. Losses in Gross Revenue to a Starting Plant	Est. Futur Operatin Expenses the Going P
1908	200411	200411	0	200411	8995
1909	208681	208681	30000	178681	9252
1910	216951	194197	90000	104197	9509
1911	225221	179323	135000	44323	9766
1912	233491	187203	170000	17203	10023
1913	241761	195083	195083	0	10280

Number of miles of Water Mains-100
Population (Approx) 80,000

TABLE AND DIAGRA
Showing Estimated
GOING VALUE

To Accompany Report of
JOHN W. ALVORD
Hydraulic & Sanitary Engr.
1212 Hartford Bldg.
CHICAGO



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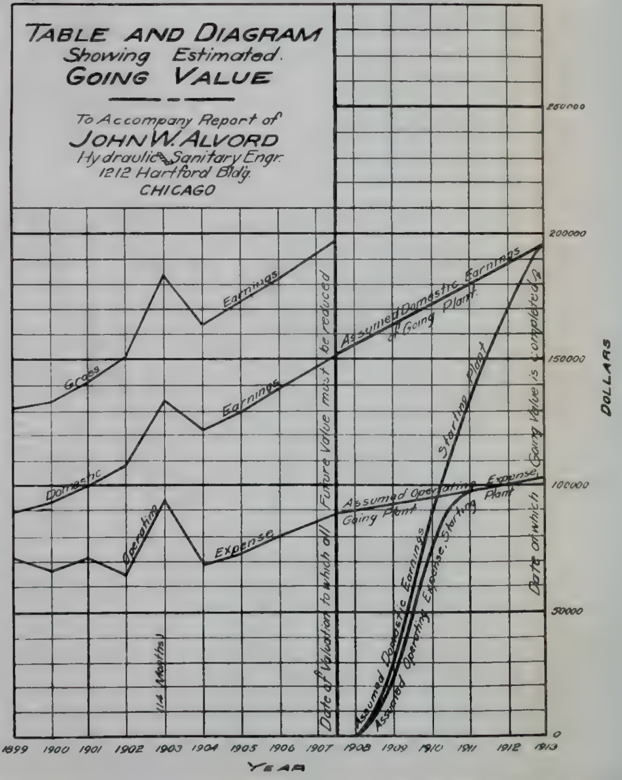
YEAR	Est. Future Gross Earnings of the Going Plant	The same less Hyd. Rentals taken over by New Plant	Est. Growth of Gross Revenue of a Starting Plant	Est. Losses in Gross Revenue to a Starting Plant	Est. Future Operating Expenses of the Going Plant	Est. Future Operating Expenses of a Starting Plant	Est. Net Credits in Operating Exp. to a Starting Plant	Estimated Net Losses to a Starting Plant	Factor for Present Worth	Present Worth of Net Losses to a Starting Plant
1908	200411	200411	0	200411	89959	0	89959	110552	.952	105246
1909	208681	208681	30000	178681	92529	20000	72529	106152	.907	96280
1910	216951	194197	90000	104197	95099	75000	20099	84098	.863	72577
1911	225221	179323	135000	44323	97669	97669	0	44323	.823	36478
1912	233491	187203	170000	17203	100239	100239	0	17203	.783	13470
1913	241761	195083	195083	0	102809	102809	0	0		

Number of miles of Water Mains - 100
Population (Approx) 80,000

Total Going Value 324051

TABLE AND DIAGRAM
Showing Estimated
GOING VALUE

To Accompany Report of
JOHN W. ALVORD
Hydraulic & Sanitary Engr.
1212 Hartford Bld'g.
CHICAGO



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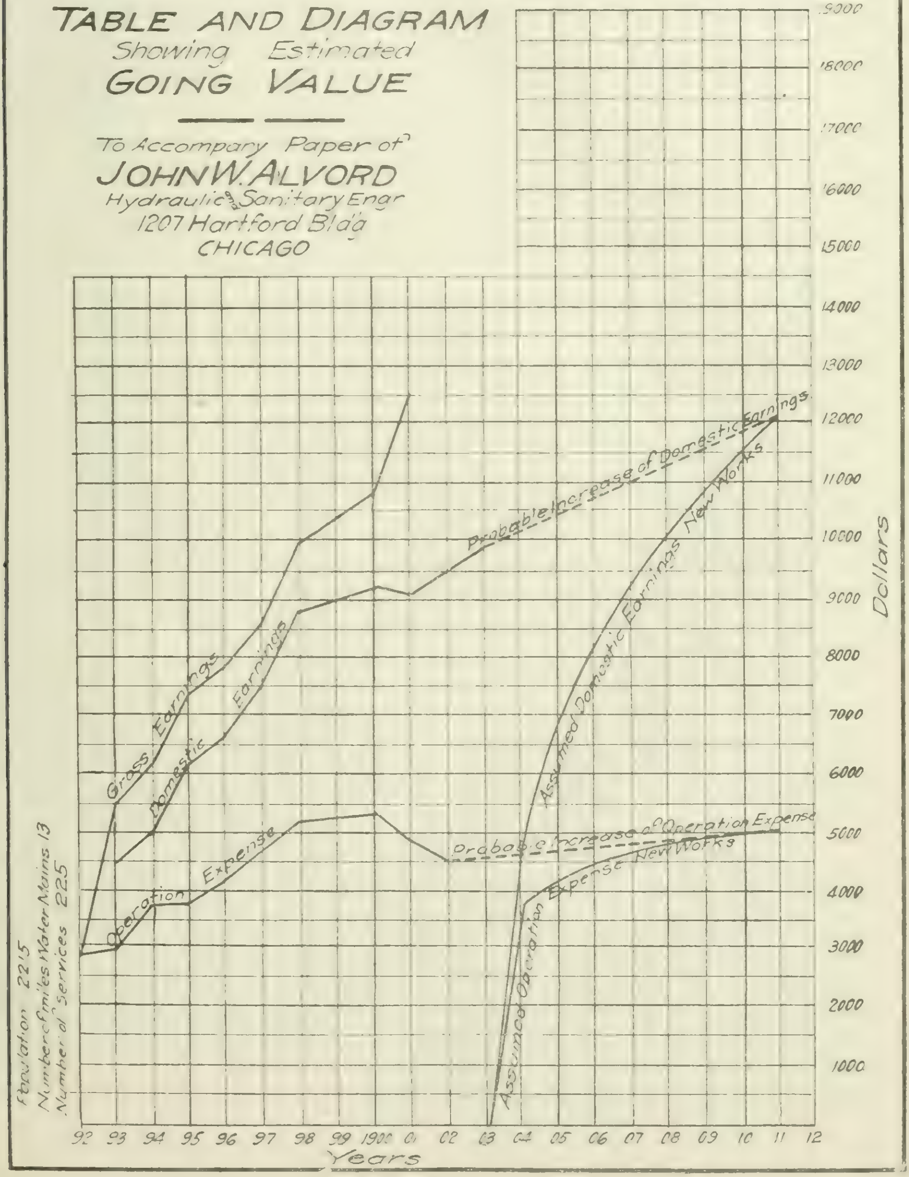
YEAR	OLD WORKS			NEW WORKS				Difference Old & New	Factor	Present Worth Going Value
	Earnings	Hydrant Rental	Total	Earnings	Def. in Operation	Interest	Total			
1903	$ 9750	4520	10270		4700	3000	7700	6570	.952	6250
1904	10000		10000	4400	800		5200	4800	.907	4360
1905	10300		10300	6500	500		7000	3300	.864	2870
1906	10600		10600	8000	300		8300	2300	.823	1920
1907	10900		10900	9200	200		9400	1500	.784	1200
1908	11200		11200	10200	150		10350	850	.746	650
1909	11500		11500	10900	100		11000	500	.710	370
1910	11800		11800	11500	50		11550	250	.677	180
1911	12100		12100	12100	0		12100	0	.645	0
										Total Going Value $ 17800

TABLE AND DIAGRAM
Showing Estimated
GOING VALUE

To Accompany Paper of
JOHN W. ALVORD
Hydraulic & Sanitary Engr
1207 Hartford Bldg
CHICAGO



CONCLUSION

This paper has extended to a greater length than intended. The subject is one which has always demanded close study and created much discussion among appraisers, and few have cared to commit themselves upon it in public writing. Excellent and conscientious estimators with long experience in other phases of water works valuations, and without serious differences among themselves in physical values, will here find their honest views diverge, sometimes to such extent as would appear unreasonable to the courts and to the public. The effort of this paper has been to show that this divergence is very largely induced by the very complex conceptual conditions which are imposed upon an estimator in dealing almost wholly with future assumed conditions, and involving in its consideration the fundamental philosophy of the theory of valuation by reproduction. The writer believes the theory of reproduction is not simple, but exceedingly complex, so complex, in fact, that it is a serious question whether courts and appraisers would not find it advantageous to ascertain what has been the past actual honest investment in any given plant and property, regardless of its appreciations or depreciations. It is not always possible to ascertain such information, and in many cases, doubtless, it will be impossible, but there is no question but that where it is possible it affords a simple and satisfactory method of valuing for the purpose of basing fair return, while for the purposes of sale or transfer some limited inquiry into appreciation and depreciation should be made in addition.

DISCUSSION

Mr. Daniel W. Mead: In the first place I wish to say that in my opinion the thanks of this Association are due the author for his presentation of such a comprehensive paper on a subject of so great interest. It is particularly fortunate that this paper has been presented by a man of broad experience on the subject discussed, for I know personally that the author has served on all sides of this question.

One of the most difficult features in the work of appraisal in the establishing of values, in fixing depreciation, or in considering the questions of "going value" is the point of view of the men who take part in appraisal work. I believe that it was Josh Billings who said "We are all more or less human." While this is found true in all lines of human thought and action it is found to be particularly true in appraisal work.

No matter how fair-minded a man may be, no matter how ardently he may desire to look at these matters fairly, he is bound to be prejudiced more or less by his point of view. I think that commonly the fact is lost sight of that the questions of appraisal, whether they be questions of valuation and depreciation or the questions of "going value," should be based on higher grounds than an attempt on one side to purchase a plant at the lowest figure possible, or on the other to get as much as possible from the sale of a plant.

It should be kept clearly in mind that in the long run matters of values of public utilities and of rates for their services must be equitably adjusted. It is true, in the case of existing individual plants, that appraisers, courts or public utility commissions may fix values or rates that are not just and equitable and that such plants may get an undue benefit on the one hand, or on the other hand feel the ill effects of unjust findings. In the long run, however, a fair return on a fair investment of capital must obtain, and unless this can be secured, private capital will refuse to invest and the public on their part must finance their own public utilities and operate them. Private capital will not, and cannot, be expected to invest unless a fair return is assured; and such fair returns cannot be based on the interest that would accrue from an investment in government bonds, but must take into account the hazards that are entailed in the establishment of a public utility of any kind and must be sufficient to maintain the investment intact, providing not only for operating expenses, maintenance, depreciation, and interest, but also for all reasonable contingencies of operation and maintenance.

The question is often raised at the present time as to whether or not there is such a factor as "going value." Many have the idea that "going value," as currently expressed, is simply a method of placing an undue excess value upon plants now constructed.

A very brief consideration of the general proposition will establish the fact that, in the building up of any business, whether it be that of furnishing water to a community or the establishment of any private business, the necessary investment is not only the cost of construction, the cost of the physical property, but that there are interest charges, costs of business administration, and costs of development, which are not costs of purely physical construction and are not, therefore, as obvious as the cost of creating the physical structure. The plant must necessarily be constructed before consumers can be secure. It must be operated, in the case of a water works, in order to give the necessary fire protection or to provide for the consumers who are first connected therewith, for some time before it will be on a paying basis. The result is, almost without exception, that after the plant is constructed expenses still go on that are not offset by adequate returns and the creation of an established and going concern is an expense that is just as real and just as necessary as any expense entailed in the construction of any physical feature of the work. It is therefore believed that it will take only a very brief study and consideration of the question to establish the fact that a "going concern" is established only at a considerable expense and that this expense is justly chargeable to the construction account of the plant. The value of this "going concern," established at an actual expense of time, energy, and money, is known as the "going value."

In a great many cases, in fact, I think, in almost all of the earlier cases, the question of interest during the time of construction was considered as a part of the "going value." Later these different expenses were to an extent differentiated, and as a rule, I think, in appraisal work at the present time the interest charged during construction is considered as purely an interest charge, and an attempt is made to establish as nearly as possible the actual cost value of the "going concern" apart from all other costs of establishing the plant and business.

To establish a "going value" which can be considered as fair and equitable, even to the mind of the individual appraiser, is a very different proposition, and to establish such a value which will be satisfactory to a full board of appraisers, is almost impossible. Men will differ radically in their conception of the various factors that must enter into this value, and the result is in most appraisals, almost without exception, that there is a very great difference in opinion when that subject is reached.

In cases of this kind we can only expect to secure substantial justice. In cases at law we are not able to prepare a mathematical formula by which substitution of certain values and exact results can be obtained. But outside of a few unfortunate cases, I believe that we all feel that in the courts of this country substantial justice is reached. We can expect nothing better in the establishment of "going value."

The arguments and illustrations that the author has used in this paper have been the results of some ten or fifteen years' consideration by a number of engineers who have been engaged in this work. The author has treated this subject fully, and, for the most part so much along the lines of my own line of thought, and has expressed it so much better than I could have done, that I shall not attempt to enter very largely into the discussion of the paper.

I notice one point, however, in the latter part of the paper in regard to which I wish to make a brief statement. The author writes, on page 201:

> It has been suggested by the writer that certain modifications may be made in going value, due to the fact that in many franchises, in the West at least, the municipality often holds an option, or right to purchase plants at an appraised valuation at given intervals of time during the life of the franchise. Such option necessarily is of value to the city holding it. Etc.

The author seems to suggest the general idea that possibly the question of "going value," or the "going value" itself, should be modified by the city's option to purchase. I believe that this suggestion is wholly illogical. The right of purchase is entirely a contract question. If a company agrees by contract to build a plant, which at the expiration of the franchise shall revert to the city, the contract is doubtless a good one, and the company would necessarily lose its entire plant at the time of the expiration of the franchise. The contract would also be valid if the franchise provided for the purchase of the plant on a valuation to be based purely on the physical features of the work. In which case, perhaps, no "going value" could be considered. I can conceive no reason, however, for refusing to consider any feature of the construction or any element of value of a plant, or of modifying such values on account of an option to purchase, whether these values be purely the physical value of a reservoir, or of installing a pumping engine, or of the cost of developing the "going value," or of the cost of establishing any other feature of the plant. All of these expenses must be entailed in the construction of every plant; and unless it is especially provided in the original contract between the parties to the franchise contract that certain values are to be eliminated or ignored, I can see no reason why the city should, on account of having the right to purchase either at the end of the franchise period or at any other time, be entitled to a reduction in the cost of the construction and development of the plant. All such rights, if exercised, have a definite value of themselves, and if a company has accepted a less satisfactory and less valuable franchise, on account of such reserved purchase rights, there seems no just reason for further depreciation of the property on account of such rights.

Mr. William Bishop: I am entirely unfamiliar with the actual work of valuation, but highly as I esteem the general trend of the paper presented by Mr. Alvord, and the scope of the discussion which has taken place, there seem to be some points which need a caution.

To the lay mind there seems to be a disposition on the part of some public utilities to reach out and grasp some intangible, elusive asset which they realize is there, and on which they frequently spend considerable money.

This is here denominated the "going value." But why should it be paid for on the surrender of a franchise?

When the viewpoint is changed this asset is no longer intangible or illusive, nor is it shrouded in mystery.

If it be conceived that two plants, identical in all respects, are built, their respective owners seek franchises, the city grants one, not the other; the difference in worth of the two plants clearly shows both the "going value" and whence it comes.

We will grant that this "going value" thus created is capable of increase by judicious management; should this increase be paid for?

When a man rents a piece of land to another, the latter fertilizes it—spends money on it to increase his revenue—when the land reverts, does the owner pay for its increased capacity?

Then why should a public utility be reimbursed for expense incurred, in an effort to increase its revenue, even though it increase the "going value" also. Any increase in the plant itself will need adjustment; but the increase in the "going value" will not.

A few years ago there came to the knowledge of the speaker a tentative offer of $2,000,000 to a city for its water plant and rights. The cost of the plant was less than $300,000 and it yielded a net income including the interest on investment of about $14,900. Under no circumstances could an increase of more than 50 per cent in net income be expected without large increase in capitalization. That is not a very enticing business opportunity; what did they want? They were after the *potential going value:* they wanted the provisions of the special franchise granted by the state which gave to the city the right to use certain waters and to lay pipes on any highway, railroad, or canal in the state.

Put an adequate plant behind that proposition and see if there is mystery about "going value" or to whom it belongs, especially if the $2,000,000 had been accepted.

DANIEL W. MEAD: In answer to the last speaker I would say that the position he has assumed is entirely illogical. He has made several assumptions that are not warranted. I would like to ask him how it would be in the case of a company that has taken an unfortunate franchise? Many of the water works plants in this country have never received a fair return upon the original cost of the construction, or sufficient to cover depreciation,—not considering the cost of creating "going value." There are many water works in this country that have not paid the men who put their money into them, one cent. They have been working under unfortunate circumstances; and in order to create the business that they have acquired, they have been obliged to go to a large expense and have made large extra investments. The city in granting a franchise is not handing over to a company a one-sided contract, beneficial to that company only. They are receiving definite value, for they are receiving the things that are necessary in order to build a city. Cities in granting franchises are perhaps throwing onto a private company a duty which may belong to the municipality itself. Not desiring to invest their own money, they are shirking their responsibility, and putting the risks upon private individuals, or a private company. That company may, or may not, make a profitable investment—out of their purchase contract. We are up against two sides to this proposition. The company may succeed financially, or they may not succeed. There are many men in the water works business today that will remember that twenty or twenty-five years ago a franchise was looked upon as a golden opportunity for reaping large returns. And many who were too eager to invest at that period have realized that these anticipations have not always materialized. While a company may in a comparatively short time reap a large reward, it might lose it several times over in other investments of a similar character. There are many water works in this state that are in the latter condition. They have never actually made a dollar upon the money investment after loss of interest, depreciation, and operating expenses are taken into consideration. Why, then, because a franchise has been granted by a city when a contract supposed to be mutually advantageous has been entered into, and when that franchise expires and the question of valuation is to be considered, should the cost of creating any one feature of that plant be waived any more than we should waive the cost of all the features of the plant?

As I have said before, these questions are purely questions of contract. If the contract provides that these matters shall be waived, well and good, no matter how unfortunate it may be, it can be legally enforced; but with a contract freed from these technicalities, where the city has the right to purchase and purchase at a fair valuation, I maintain that the valuation should include every dollar of cost that is honestly put into development of that plant. I believe as we look into the matters more at length we will all come to that general conclusion. I should perhaps have said in the first place that this matter of "going value" is one that is well established in the minds of all who have given due attention to appraisal work. We should certainly look at it from every side of the question. We certainly want to get expressions of as broad a character and from as many viewpoints as possible, in order that ultimately we may reach the basis for a fair decision; a fair basis of estimating this intangible but no less real value of every public utility.

Mr. Wm. Bishop: We are told the position assumed is "illogical" because several assumptions were not warranted. The only things assumed are—

(1) That "going value" is that increased worth of the plant which comes by reason of the operation of the plant.

(2) That "going value" is dependent upon the franchise.

(3) That, being dependent upon the franchise, the "going value" goes with the franchise and belongs to the owner of the franchise.

These are the assumptions: Are they logical?

(1) Surely the definition of "going value" is the same as that in the mind of the last speaker when he differentiates between it and the cost of construction of the plant.

(2) By increasing your plant, your "going value" can be increased indefinitely until the moment the limit of your *franchise* is reached; that moment the increase of "going value" stops. "Going value" without a franchise is nothing, it reaches its maximum when the franchise is utilized to its maximum limit; therefore "going value" is dependent upon the franchise.

(3) Is not this a self-evident proposition? Transfer your plant to some one else, the "going value" will go on just the same. Transfer the franchise to some one else, do you still retain your "going value" with the plant?

Then the owners of the plant have something they own and something they do not own, both of which they are developing for their own interest, when the time comes for the reversion of that which they do not own, a little common sense should be used and the ordinary laws of reversion be applied.

Will you kindly point out the flaws in the logic?

In answer to the last speaker, I would like to ask what difference it makes to the principle whether the franchise was an unfortunate one or not?

It no doubt affects the whole value of the plant, but it does not affect at all that portion which belongs to the public utility, excepting in so far as it may have demonstrated the inefficiency of the plant itself; and if the city which gave the franchise is purchasing the plant, it is worth just as much as if it were earning large dividends.

As a rule public utilities—(it may be that occasionally their origin is philanthropic)—are formed with the belief by their stockholders, that they can be made to pay; and they go to the municipality with certain propositions in order to get their franchise, which of necessity is an asset of value.

There is grave reason to doubt whether any city or other government which does not own its streets in fee simple, has any right to grant a perpetual franchise; hence in every such case public utilities must look eventually to surrendering their franchises to the city again, and why the city should be expected to pay for that part of the value which its own act created, is passing strange.

It must be kept in mind that the city or municipality is the *people*, and every charter honestly gotten is given by them or their representative body; whatever may be the reasons why they have not utilized the rights they now delegate to others, we are bound to believe that to them these reasons seemed good and sufficient; when any differ sufficiently to seek the neglected opportunity, though they may be doing a work which the municipality itself ought to do, though the city may reap great benefits from it, even though undertaken because of encouragement by the municipality itself, they must stand or fall by their own judgment.

Every individual, every public utility, when the time comes to surrender privileges which have been granted, is entitled to a just settlement. No governing body has a right to take advantage of forced liquidation; on the other hand public utilities have need to remember that all they have to sell, is what they hold in *fee simple* or equivalent title.

MR. D. W. MEAD: In regard to the assumption made by the last speaker, I would say that the first assumption, if correctly interpreted, is practically correct,—the second and third are, however, in error. While the "going value" is the increased worth of the plant which comes by reason of its operation, such "going value" has been created by an actual expenditure not usually considered as a portion of the cost of the installation. This expenditure is, nevertheless, just as much a part of the cost of placing the plant in running condition as any cost of installing any of its physical parts. For example, let us suppose that a plant has cost $250,000 for its physical construction. This sum has been expended to provide an ample water supply, construct the station, purchase and install the pumps and lay the water mains and appurtenances. The plant is now ready for operation but has no consumers. As soon as completed the plant must begin operation for purposes of fire protection or to provide for the first consumer. A force of men must be at hand at the pumping station day and night. The pumps must be operated regardless of the quantity of water furnished. For several months, and possibly for several years, the income is not sufficient to pay operating expenses, not considering interest and depreciation which go on day and night regardless of the number of consumers. If the business of the company is conducted on proper lines, an interest and a depreciation fund will be set aside from moneys provided by the original financial arrangements to meet these expenses, and finally, it will be found when the plant actually begins to earn a sufficient sum to cover operating and fixed charges that the actual cost of the works up to that date is considerably above the original $250,000 cost, and will, let us say, approximate $300,000. This extra $50 000 invested is the amount that has been required to create a going concern and is as legitimate a charge against cost of construction and value of the going plant as any other part of the installation. Going value *per se* is entirely independent of the franchise, although the compensation received for this element of value as well as for the value of every physical feature of the plant may ultimately depend upon the franchise. If the plant cannot be operated without a franchise, the "going value" may be seriously affected as far as the company owning the plant is concerned. The same may be said of the mains, the pumping engine, and every other physical feature of the work. For if the franchise expiration terminates the operating period of the plant, the only value left may be the scrap value of the physical features of the plant. No thinking man advocates such a basis of valuation at the present day.

How "going value" should be treated in various cases is, perhaps, a matter for argument and depends upon the questions involved.

The Wisconsin public utility commission in its recent findings in the case of Payne and others, of Marinette, against the Wisconsin Telephone Company states:

> If property is devoted to the public use and reasonable care has been exercised in all the phases of its management, but the owners have not yet received a fair return during the earlier years of the operation of the plant in which the property is used for the convenience of the public, the deficits thus incurred must be made up out of later earnings in so far as this is commercially possible and expedient.
>
> In other words, every effort honestly put forth, every dollar properly expended and every obligation legitimately incurred in the establishment

of an efficient public utility business must be taken into consideration in the making of rates for such business. Collectively, the elements just referred to may be designated by the term "going value," and in this sense there can be no question regarding the propriety and justice of admitting "going value" as a consideration in the determination of rates. Whether this "going value" should be made a part of the permanent capitalization of the plant or provided for by means of a sinking fund, or other fund, is a matter to be decided on the facts of each particular case. If it is made a part of the capital investment, it becomes a permanent charge against consumers for all time to come. If it is provided for by means of a sinking fund, all persons who are patrons of the plant during the period in which the sinking fund is accumulated will alone contribute.

The fairness of this proposition cannot be questioned.

It may make no difference in one sense as to whether a franchise has been fortunate or unfortunate, but the last speaker assumed in his first remark, that all water works companies have received adequate returns, which is not the case. True justice, either in the establishment of rates or values, should certainly take past consideration into account, and if the earnings of the company have not been sufficient to amply liquidate the cost of creating its business, then such expense must be recognized, both in the establishment of rates and in the final valuation of the plant.

I agree with the last speaker that "every individual and every public utility when the time comes to surrender privileges granted by municipalities, is entitled to a just settlement," and that no valuation should be based on forced liquidation. This principle requires a careful consideration of every element of value in the plant, and the "going value" must fairly come in for its due consideration, and in almost every case, is a credit that must be recognized. This fact is becoming so well established as to be almost beyond question, as witnessed by several recent public utility discussions.

Mr. A. A. Reimer: I think that to any student of economics the question of the reality of "going value" of any public utility is not open to much discussion in his own mind, for certainly there is a real value attached to it. I do not care to discuss that matter now because it has been pretty fully discussed by Mr. Alvord and others. There is just one point I wish to touch upon, and that is the last point brought out by Mr. Alvord in his paper, with regard to the city's option.

It seems to me that that particular matter is open to very grave question as to whether it should be considered either for or against the would-be purchaser, that is, the municipality.

If we as engineers or contractors enter into a contract to do certain things, we expect to live up to the provisions of the contract, and we figure the cost of so doing, and I believe that the same rule holds when a private company, a public utility company, takes a contract—for that is all a franchise becomes in one sense of the word. By it there is given the right to do certain things provided other things are done in return. The operating company is legally bound to do certain things under that franchise, and the cost of doing these has been figured before the franchise is taken.

It seems to me that if an option clause to buy on the part of the city is in the original contract that nothing should be deducted or added, when the time comes for a city to exercise the right it holds under this franchise, or contract, which ever you wish to call it. For that reason I cannot see what it was that actuated Mr. Alvord in giving some value to this option clause in the cases that he mentioned in that closing paragraph, but I would like to know what it was that led him up to the point where he was willing to ascribe some value to it.

Mr. J. W. Alvord: The causes actuating me to advance this opinion are perhaps put forward in rather a tentative way, and I shall have to admit that the proposition was purposely so stated in order that I might invite criticism. Apparently I have been successful.

The thought is not one that has been very fully discussed by appraisal boards, not fully enough discussed to even satisfy myself that we have seen it from all of its various aspects. I do not know if I am prepared to fully discuss it myself; I have a few clear ideas about it which I am certain are right. They are these: That the option which the city holds to purchase after, we will say, a five years' interval, is a valuable right. I think you must all concede that it is a valuable right; a right that no one else possesses; a right which in a profitable enterprise, at least, some one may be very desirous of possessing.

The city has foreseen that it would be a valuable privilege, and they have reserved to themselves that privilege. Now take the case of a profitable plant. I have in mind one case that was a very profitable plant and in which the value of the option was very apparent. The company resisted very strongly the attempt of the city to purchase under that optional clause all the way along the line, because they were enjoying a very profitable business. The city had by its contractual relation reserved the right to acquire this plant, this business. Now if it is true that it is a valuable privilege, there must be some method of valuing it. If any one else holds it it will not apply; if the city holds it, they ought to acquire it. If they do acquire it, how are we to measure it? That is the first part of the proposition. The second part of the proposition is that going value is in reality made up of two parts. The first part is the part due to the fact that while the plant is being constructed it is not earning anything. The second part is due to the fact that after the plant is completed it must then, and then only, begin to acquire business. The second part of going value is usually paid for in cash. It is a cash outlay straight through. Our attempt to measure it is only an attempt to estimate the value of the cash that has to be paid in to reproduce it. The first part of the going value is not a cash outlay on the part of the company, but it is an advantage which after years of time they acquired as against all newcomers, as a sort of unearned increment.

Now take the case of a city that is considering the question whether they will build or buy a utility that is already in operation. It is obvious that if they have no option they must forfeit this consideration. If they build they must lose revenue while they are building. Therefore this real advantage which the utility company holds is worth paying for, although the company may not themselves have paid anything for it. That part of going value it seems to me is closely connected with the fact that the city have had the foresight to reserve to themselves the privilege of purchase, in the form of a valuable option. That is as far as I have gotten in my own mind. There may be things about that I do not yet fully see; but I cannot conceive that going value, like a pump, for instance, is a completed thing. I conceive it has an intangible value which necessarily depends upon the conditions surrounding it. If conditions are such that the city has reserved the right to at once step into the position of the utility company without having to undergo the necessity of awaiting the construction, either actual or theoretical, that right has some value, and that value is pretty justly and properly measured by the loss of revenue during a theoretical reconstruction, which is the first part of going value, the part that resembles an unearned increment.

Mr. D. H. Maury: I have read Mr. Alvord's paper with a great deal of interest, and with a great deal of gratification that he should have given to this association so extremely valuable a contribution to its literature.

In reading it I was impressed from the very start with the pure logic of his argument. He seems to start with a fair and unbiased mind, and to present his reasons, step by step, in so clear and logical a manner that no one who gives the time to read the paper carefully can fail to be impressed with the fact that a man who knows his subject is taking infinite pains to make it [illegible] note of Mr. Alvord's paper. Turning, however, to page 201, my attention was at once attracted by the statement put forward, as Mr. Alvord says, in a very tentative manner and not as a certainty; but the same statement, to which reference has already been made by Mr. Mead and Mr. Reimer, and which appeared to me to depart at once from the logical path which had been heretofore followed by the author.

An option to purchase is an option to purchase. It is one of the considerations of the contract. It is one of the benefits which the city receives from the company under the agreement. It must be measured by its terms, and nothing should be read into those terms which is not there, or which could not have been contemplated when the terms were drafted. I do not think any one can say that any option clause in any contract ever contains, in addition to the provision that the city shall have the option to purchase, the further provision that when it exercises this option, the appraisal shall not be made in the usual manner, but that the appraisal shall be made in a manner entirely different, which shall take away from the going value

ERRATA.

Page 221, first line third paragraph, read 194 instead of 190, first line fourth paragraph, read 205 instead of 201.

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I quote from the paragraph on page 190.

> If going value is reasonable at all, it is reasonable because it is logical; and if logical it must be founded on data that are logical.

That, until I reached page 201, seemed to me to be the keynote of Mr. Alvord's paper. Turning, however, to page 201, my attention was at once attracted by the statement put forward, as Mr. Alvord says, in a very tentative manner and not as a certainty; but the same statement, to which reference has already been made by Mr. Mead and Mr. Reimer, and which appeared to me to depart at once from the logical path which had been heretofore followed by the author.

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I do not think that any contract was ever drawn in which either party ever contemplated that that construction would be placed on the option clause. Therein I think that Mr. Alvord departs from the logical path which he has followed up to that time. In his laudable desire to do justice to both sides, he seems to be confronted with the necessity of putting a value on this option, which as he conceives and truly says, is a valuable thing.

The duty of the appraisers, however, is to determine the fair value of the water works property. They are not appointed to value an option to purchase; and unless the option to purchase should contain some definite provision to the effect that the city, in exercising the option, should have the right to exclude certain definitely specified elements of value, then the appraisal should be made in the usual manner, and with no deductions whatever on account of the option clause.

It should be at once admitted that an option to purchase under appraisal may be a thing of great value.

Let me suggest as a fair construction of the value of that option, that it be considered as the difference between the valuation made as a result of a fair appraisal, an unbiased appraisal, and the price which might be put on the plant by a company which saw its opportunity to hold the city up to a value greater than the actual value,—which it might do if the city wanted to purchase and did not have the option to purchase. That is the only value which, so far as I can see, inheres in an option. I certainly cannot see how so strange and forced a construction can be put upon language so perfectly clear and plain, nor how any one could assume for a moment that the language of a simple option to purchase could be construed along the devious path that leads up to the estimating of the "going value" in two separate items, and to the offering of one item to one party and the other to the other party.

Now coming to a minor detail of the paper, I was interested to note on page 193, under the heading, "Recovery of Revenue," various items which should influence fair-minded appraisers in figuring the going value and arriving at it by the detailed methods laid down by the author. Right here I should suggest the use of a slightly different term from that employed by the author. I think that "Acquirement of Revenue" would be a better term, because a new plant has never had revenue, and therefore is not recovering it.

Under item (*c*), the author mentions "The physical possibility of connecting and plumbing large populations," as one of the things to be considered.

I think it should be realized that the organization of a very greatly increased local plumbing force will require time in any community. If plumbers who have been conducting the business of connecting up water works services to houses, and installing house fixtures inside, have been accustomed to put in three hundred to five hundred services in the course of a year, and then are suddenly called upon to put in as many as they can, I do not think that in the first year they would be sufficiently organized to do the work. I do not mean organized into unions, because the further danger arises right there that they may be so organized in the unions, that when you call upon them to do the work they may offer obstructions. What I am referring to is the matter of getting the plumbing work done, and the difficulty in doing this the first year by a sufficiently augmented force. The writer infers that the services will perhaps go in at a greater rate during the first year. I am rather inclined to believe that service pipes will go in at a greater rate the second year than the first year, and that then the rate at which they are put in will begin to taper off.

One other consideration that I think might well be brought forward here is this: pursuing the details of this calculation of revenue on the broad principle of what is "humanly possible," laid down by the author, it is not right to assume that the starting plant, in taking on, for example, three thousand services the first year, will actually get the full revenue from those three thousand services that year. There is the freezing season, which in the average town in this country begins, say, in December and lasts along to and through the first two or three months of the following year. So that while there may be three thousand services put in during any year, the average date at which they are put in will be about August 1, so that only about 40 per cent of the total average annual revenue will be realized from them for that year.

As to going value, I believe that a fair estimate of going value can only be made upon the assumption that the rates charged by the corporation are fair rates. If the rates are too high, it will be unfair to give to the corporation a going value based upon these excessive rates. If the rates are too low,—with the same volume of business represented as in the case of the higher rates, the same length of time of service, the same number of connections, the same time required to build up the business,—if the rates are too low, it would be equally unfair to mulct the company by basing its going value upon rates which are not sufficient to pay the proper returns.

It has been stated, perhaps not in this connection strictly, by my friend Mr. Metcalf, in a most admirable paper which I think ought to be in the hands of every one who is interested in this subject,—a paper which was recently read before the American Society of Civil Engineers—that to attempt to determine going value upon a basis of fair rates would be to argue in a circle, because to increase or reduce rates would be to increase or reduce the going value; and one would have to determine two unknown quantities, and therefore could reach no definite conclusion.

At first blush that would seem to be true, but it is not strictly true. It is true that you cannot make an algebraic formula which will lead you at once to the correct result; but there is one constant element in the calculation which holds you solidly to the ground, and that is the physical value, which does not change. Now the method of procedure in order to calculate going value on fair rates would be about this:

The estimator would take the actual rates; he would know the physical value; he would figure the going value at the actual rates; he would add the going value to the physical value; and see whether the actual rates gave a fair return. If the actual rates gave too low a return, then he would raise the rates to another figure, and make a new calculation of the going value, add it to the physical value, and see whether the rates gave a fair return. The second time he would probably be closer to fair rates and to a fair going value; and so, by a cut-and-try method, he would ultimately come nearer to correct results, in proportion to the number of approximations that he made, finally arriving at reasonable accuracy.

In conclusion, I repeat that this association has reason to be very much indebted to Mr. Alvord.

Mr. Leonard Metcalf: As one of the younger members of the Association I have some diffidence in rising to speak on this subject; but it seems to me that Mr. Alvord has done such genuine service to this association and to those interested in water works valuations that it would be unseemly for me not to rise, having been very much interested in this general subject, and having given it a good deal of thought and study. No one could read Mr. Alvord's paper without recognizing that it was written by a fair-minded man. I know of no subject, as Mr. Mead has said, and ably said, which requires more careful consideration, greater freedom from bias, and greater breadth of knowledge than this question of water works valuation.

Perhaps it would be of interest in connection with this discussion to revert to the difference in forms of franchises which have prevailed in different parts of the country, because it seems to me that that has an important bearing upon the question of valuation.

In the east the majority of our franchises for water service have been what are popularly known as perpetual franchises, or, if not perpetual, at all events very long-term franchises. That leads to a very different state of affairs from the franchises with which you are more familiar in this section of the country, which are limited to short periods of fifteen, twenty, twenty-five or thirty years.

Now, while it is true that the present-day tendency is toward reserving to the public, as I believe should be the case, the franchise value,—that is, the value which arises from the right to do business and to enjoy the future increase in profit in the business,—we must not forget that the older works which were built under different conditions are deserving of a just recognition of the conditions under which the contracts were made. It is true that, in the last ten or fifteen years this fact has been increasingly clearly recognized, as any one who has studied some of the English cases, more particularly the London water works valuation cases, will know, from the sterilization clauses, so-called, which have been introduced into those contracts; clauses which were definitely drawn to retain to the public any increment in value growing out of franchise rights. The same desire has been recognized in Massachusetts in more recent years in reserving to the community all increment in franchise value in water and in gas works, so that these public utilities may be bought or taken under arbitration proceedings at a later period, by the public, without its having to pay for the franchise element of value.

In this particular matter which has been raised by Mr. Alvord in this last clause on page 201, referred to by the previous speakers, it seems to me that he has touched upon this very franchise question, and perhaps a separation, if that is possible, a mental separation, a mental conception of the difference between the going concern value as an element of value and the franchise value will be helpful, difficult as I recognize the consideration of this subject to be.

Broadly speaking, we may consider that in value we have certain elements to consider, the original cost, the reproduction cost, the going concern value, and the franchise value. There is a means which Mr. Alvord has beautifully outlined, of figuring the going concern value. The reproduction cost of a new plant can be figured closely, and it has been my experience that experts in figuring reproduction cost usually arrive at estimates within from two to five per cent of one another. On the depreciation question, which bears upon reproduction cost, there is a greater divergence of opinion. But there is no known method, so far as I am informed, of figuring independently the franchise value. The method which has usually been used has depended upon capitalization of the earnings of the company, and then a subtraction of the other determinable elements of value, and the throwing of the difference into franchise value. That method is open to certain dangers, to one of which Mr. Maury has alluded, if it means that the larger your earnings are the greater your capitalized value, the greater the value as figured by capitalizing the income. That method is open to the objection that it does not give proper consideration to the question of the fairness of the rates, which is, of course, of great importance.

Referring to the matter of which Mr. Maury has spoken, (making allusion to the paper recently presented by me before the American Society of Civil Engineers) the objection that I

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Referring to the matter of which Mr. Maury has spoken, (making allusion to the paper recently presented by me before the American Society of Civil Engineers) the objection that I raised to the decision which he has quoted, which was the decision in one of the Maine water works cases, known as the Waterville case, was that it assumed premises which made determination of value impossible; for the court held that the water works were entitled to a reasonable profit based upon value of its entire property, including franchise value, and based also upon fair rates. But the only known method of determining the franchise value involves capitalization of rates, and these same rates are based upon this franchise value in part, not solely upon cost or investment, as Mr. Maury suggests. How could you then measure or determine the fairness of the rates? There was not under such requirements, as you see, any definite starting point; the higher the rates the larger the net earnings and hence the apparent franchise value, or the higher the value placed upon the franchise the higher the rates could be without being unreasonable, since the rates were by order of the court to be based upon the value of the company's entire property as a whole, including tangible and intangible property, franchise and going concern values as well as physical values.

As a result of the Waterville litigation and other suits affecting some other works owned by the Maine Water Company and allied interests in Maine, another opinion was handed down by the Supreme Court of Maine which has further elucidated the views of Judge Savage (who wrote the Waterville opinion) and which has been of great assistance to experts interested in this subject.

Judge Savage's later theory, as laid down in the Brunswick opinion, written by him, is fundamentally this,—I speak of it particularly because it has a bearing on what one of the previous speakers has said in regard to the reservation of franchise rights to the public,—the rates must be based on cost as an element of value, but that it must not be assumed that the original or reproduction cost solely shall be used for this purpose, for if the community did not elect to take the responsibility of building the works and to take the chance of loss, it is not entitled to have the earnings or the rates figured on the bare original or reproduction cost. In other words, it is to be assumed alike from the point of view of the water company and of sound public policy that the public at the time of construction would have been and was willing to pay more for the service, or to pay a return on a larger capitalization, than would be represented by the actual investment, rather than to undertake the risk involved and build its own works; this leads to the suggestion that it is reasonable to increase the cost of the production of the works or the reproduction of the works, by a certain sum upon which the projectors or the builders of the works shall be entitled to earn a return in the same manner as upon the capital actually put into the plant. Now I do not care to take your time or to weary you with a full discussion of what all that means. But it seems to me that it does give a definite starting point for consideration of the rating problem, also for valuation, which we did not have before the Brunswick opinion was handed down.

In Mr. Alvord's paper there is one assumption to which I want to refer, which bears upon this point and upon this quotation from page 201 which has been referred to. Mr. Alvord assumes in figuring his going concern value that the new plant which is built shall continue in growth until it overtakes the income of the old plant, and he assumes further that the old plant shall continue to gain in income during this period of years after the date of taking until the new plant has overtaken the old. In other words, he figures his going concern value, not upon the present income as of the date of taking, but upon the projected income, when carried forward for a certain period of years corresponding to the interval of time required for this development. Does not that, gentlemen, pertain in some measure to franchise rights,—to the increment in income,—rather than simply to the going concern value, which has to do with the establishment of the business and of the income existing as of the date of taking?

In other words, is it not true that the portion of the income which is in excess of the present income, as of the date of taking, is really an increment which the company will enjoy as the result of its franchise rights? It seems to me that it is this value which may be considered perhaps as the measure of the city's right to take the plant previous to the expiration of the contract period, provided the contract is so drawn as to give the city this right.

From my present point of view, if you admit that you are

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From my present point of view, if you admit that you are figuring a going value concern upon the present income of the works rather than upon future income, it seems to me that there is merit in Mr. Alvord's suggestion.

Now, just one word more in regard to methods of valuation and point of view. William S. Wallace, Esq., a very able corporation lawyer of Philadelphia, presented last winter before the Pennsylvania water works (managers) association a paper in which he discussed certain questions relating to valuation, and summed up the difference between the Pennsylvania and the Maine decisions on water works valuation so admirably that I am tempted to tell you in a few words what he said. In substance, he said that the attitude of the Pennsylvania court is to assume that the property is entitled to the income which it is earning if it is a reasonable one,—to a reasonable income, provided it can earn it. In the Maine court opinions, to which he refers, he says the court has a double standard,—first, the worth of the service to the consumer, and second, reasonable earnings for the water company. The two standards are not very different under most circumstances and lead to the same result under reasonable interpretation. The Maine standard is perhaps the safer from the public point of view, making in fact the worth of the service to the consumer the final criterion; but the Pennsylvania court opinions may lead to the same result, provided we take a reasonable standpoint in determining what is a reasonable income. And after all a fair standpoint is absolutely necessary and of greater importance in valuation than the angle or theory from which you view the matter.

Mr. Alvord has referred to the conceptual angle of a "humanly possible" state of affairs, and I think that he has outlined the essential points to you admirably. I have sometimes tried to express the same idea, when I have met men who were inclined, as it seemed to me, to make the smallest possible allowance for reproduction cost and everything else, by saying that in a water works valuation you are not entitled to make your valuation from the point of view of "hindsight;" you must do it from the point of view of "foresight," for there are always, as you as practical men know, unexpected expenses of construction and operation in the early years which must be considered in figuring the cost of reproduction.

Mr. Dabney H. Maury: I should like to thank Mr. Metcalf for making clear the distinction between the conditions obtaining when the franchise value has to be appraised, as in the case of a contract involving a perpetual franchise, and those which exist when the franchise value is excluded.

In the former case, as he correctly says, the whole valuation would usually have to be determined by capitalization of income, the physical value, going value and franchise value, all being included in the gross result. Except in a case such as the Waterville case, where the Judge held that the franchise value must be considered in fixing fair rates, it would always be possible to determine fair rates and fair going value after having figured the physical value; and the difference between the whole value found by capitalization of income, and the sum of the physical and going values found as previously explained, would represent the item of franchise value. This separation of the total value into its component parts might not be at all necessary, but it would at least be an interesting exercise for the minds of the appraisers.

Mr. Metcalf raises another very interesting question when he asks whether that portion of the gross income which is in excess of the actual gross income at date of taking is not really an increment which the company will enjoy only as the result of franchise rights. There would certainly seem to be some ground for the argument that to include this increment would be to include a part at least of the franchise value.

After listening to this admirable paper and to the able discussions which followed it, Mr. Metcalf's question is, I believe, the only one which has raised any doubt in my mind as to the manner in which going value should be calculated. While I confess to some uncertainty in the matter, I am still inclined to believe, for reasons which I shall not take your time here to explain, that the increment referred to should in fairness be included as a part of the going value.

But this question is, I feel sure, one which should be settled for all time by appraisers at the outset, in defining broadly the methods by which going value should be arrived at.

I cannot conceive that a simple option to purchase at a certain time, under an appraisal made to determine the fair value of the plant at that time, can mean anything more or less than what is specifically set forth by its terms. The option may be of great value to the city, for unless the city had the option, the company might force the city to pay far more than the value of the plant. But it is no part of the appraisers' task to determine the value of the option, and a simple option cannot affect the value of the plant nor alter the method of determining that value.

Mr. W. H. Winslow: I would like to ask Mr. Alvord if his conception of going value includes the possibility of its having a negative value; that is, is it the same as the business value? Now in ordinary business relations when a business that has been running a number of years is offered for sale people may be willing to pay for it just what it costs to reproduce it, or they may be willing to pay more, or they may desire to pay considerably less. Now does this total value, this going value, necessarily have a positive character? Assuming it possible that a water plant like a great many other businesses may be of less value after a given number of years than its original cost, because conditions are such that it cannot earn a reasonable return on the cost, now if that is the case, is your conception of going value such that it may have a negative value?

Mr. J. W. Alvord: If I catch the meaning of the question I would say, as I have attempted to answer in my paper, that the negative feature of going value perhaps would be the destruction of the physical value. As long as there is any income it is doubtless the fact that it has cost something to produce it. When all the income is destroyed the going value is destroyed, but with it also the physical value is destroyed; and if I clearly catch your idea you might assume that the going value is a negative value; in fact when it is lost the physical value begins to suffer or is destroyed.

Mr. W. H. Winslow: The idea is this, that in buying a concern no one would pay its structural cost unless it was earning at least the market rate for money.

That might be 4, 5, or 6 per cent. As I read your paper it did not seem to me that your idea of going value was practically synonymous with the business value. It seems to me according to your idea that it must have a positive value. Then you assume that the total value is worth more than the cost to reproduce the plant as long as it is earning anything. That is different from the business value, because the business value of the plant is less than the reproduction value unless the income is equal to or higher than the value in the market. If we assume that the value of a plant for the purpose of sale is distinct from its cost or reproduction value when its earnings are greater or less than the ruling rate of money, why then I think my position is right, that the city should pay simply the structural value, and that would be so whether in one case it would pay less than the plant was worth and in the other case it would pay more. Certainly no franchise or contract either ever stipulated that the city should have the right to purchase at a certain time and that it should pay more or that it should pay less than the plant was worth. This may be something entirely different from your conception of going value. If it is, why then it is not particularly relevant; but that is what I wanted to get at, whether this going value was according to your idea synonymous with the business value. If that is the case it must have a negative value unless the revenues are at least equal to the fair rate of interest.

Mr. J. W. Alvord: I do not think the going value is at all synonymous with business value. Going value is the cost to reproduce the income. You may have so small an income that the property as a whole is very much depreciated as to its business value, but nevertheless the income which it has is worth something, it has cost something and has a value over that of a plant with no income. That is my conception, at least.

Mr. W. H. Winslow: Of course the negative situation would never arise because as long as a company was not earning a fair rate of interest the city would prefer to let them continue to enjoy the situation.

Mr. H. F. Dunham: It often happens that a property which does not earn a revenue that would make it attractive at the moment has still a value in excess of cost because of the outlook for the future. This is with regard to the simple market value. The same reasoning would apply to any other than water works property.

In the early part of the paper under discussion particular mention is made of an imaginary plant, yet there are references to the necessity for fixing in mind an imaginary plant that closely resembles the actual plant. In the first reading it seemed to the speaker not irrational to drop the idea of an imaginary plant and to keep in mind only the plant under consideration as far as it can be described and the facts learned in regard to it throughout its history and up to the date of appraisal. So it was with greatly increased interest that the speaker found on the last page of the paper this paragraph:

> The writer believes the theory of reproduction is not simple but exceedingly complex, so complex in fact that it is a serious question whether courts and appraisers would not find it advantageous to ascertain what has been the past actual honest investment in any given plant and property regardless of its appreciations or depreciations.

This seems to coincide with the idea in the speaker's mind when considering the relation between the imaginary plant which is the subject of the first two pages of the paper, and the actual plant which may be under appraisal.

MR. J. W. ALVORD: Of course the theory of reproduction is only one method of finding value, there are other ways of finding values. The value of a plant may be found by its first cost, the actual investment, plus its appreciation, or minus depreciation. It may in some exceptional cases be found by its market value, if there is a market value; and the courts have well said that all these elements of finding value should be considered. Necessarily here we are confining ourselves in considering going value to the method of reproduction. I think that should be clearly borne in mind. Whether it is the best method in any particular case will always depend upon local circumstances. In many cases it is impossible to get the past honest investment in the plant, and therefore we are forced to the method of considering what it would cost to duplicate it.

MR. DANIEL W. MEAD: I want to say just one word that I think is important at this time, in answer to Mr. Winslow's question. I believe that the question of going value as ordinarily conceived in this part of the country is entirely apart from the question of business value. It is believed that there should be a fair return from every public utility, based on an honest investment and a reasonably well constructed and conducted plant. That being the case, the question of whether or not the plant is earning would not affect the fact of the going value.

The plant would have a going value even if it were losing money because it would lose less money having an established business than if it had no business whatever. So that under my conception of going value it is always a positive element, and is entirely apart from the business value. I think that that explanation is necessary to clear up the matter.

Mr. D. B. A. Graham: Being one of the younger members of this society it is with great diffidence that I venture to express any opinion upon the subject which is now under discussion. In my mind, however, there is a very clear distinction between "going value" and "business value" when considered in water works valuation. In regard to the question brought up by Mr. Winslow, therefore, I would like to mention a few things which may help to put this distinction in a clear light. As Mr. Alvord has said, and he lays special emphasis upon this point, going value is the cost of reproducing the income of the company, and therefore, if this income is positive, however small it may be, the going value also must be positive.

In plants where the franchise gives the city the power to regulate rates, and this is almost universally the case, the size of this income and consequently the business value, as Mr. Winslow defines it, is regulated by the city. If, therefore, the income of the company is so low as to make this value negative it is neither logical nor fair to cause the water company to suffer a decrease in the value of its plant on account of conditions which are beyond its control and which are entirely independent of those found in ordinary competition. If the theory suggested by Mr. Winslow was put into practice we can readily see that a city contemplating the purchase of a plant could absolutely destroy or render negative the business value by lowering the rates just previous to the valuation of the plant.

Mr. Wynkoop Kiersted: Mr. Alvord's paper on going concern value is timely, and he is entitled to sincere thanks for having given to the association this interesting paper. The writer has perused it with much interest and is loath for want of time to enter into a discussion of the many important points which the author has raised in his thorough and characteristic way. It has been the writer's good fortune to have personally discussed going concern value with Mr. Alvord on various occasions during the past few years, and he had hoped to see some simple method presented for computing going concern value, particularly in view of the inherent weaknesses in some at least of the methods thus far employed both in the assumption upon which the line of reasoning is based and in the reasoning itself. This fact is apparent from the wide variations of individual views upon the subject.

An attempt to establish a rule based upon scientific lines of reasoning and upon earning capacity only is sure to result in a fallacious conclusion to a greater or less extent, for the simple reason that the premises upon which the line of reasoning is based are to a degree mere matters of assumption allowing of a wide range of individual imagination and unlimited argument.

A properly designed, well constructed and thoroughly maintained physical property is the foundation of all values, and for this reason going concern value cannot depend wholly upon earning capacity as separate and distinct from the value of the physical property. Moreover, equitable earning capacity depends upon equitable rates, and equitable rates depend primarily upon the fair value of the physical property. Earning capacity and going concern value, franchise value, patronage, good-will, and any of the other elements of value or the considerations which go to make a successful public utility, cannot endure without a substantial, well maintained and developing physical property. While in fact structural value dies with the loss of earnings, still it is also a fact that there can be no substantial or permanent earning capacity without a substantial, well maintained, well organized and well managed physical property. This is the history of every public utility; it is the history of every piece of property artificially created and subject to the wear and tear of continuous use. Moreover, two pieces of physical property having precisely the same net earnings, but of wide variation in the matter of the cost of reproduction, may have a variation of going concern value distinct and separate from the variation due to the inequalities of the cost of reproduction. The condition of the water service as well as the cost of reproducing it is a factor for consideration.

An element of consideration the author seems to have overlooked in his discussion is the hazard to which a property must be exposed which is constructed at a cost much in excess of that needed to meet present requirements of the community in which the public utility is located. This hazard exposes the owner of the property to serious loss of interest upon his legitimate investment, to serious obstacles in the way of financing the property, and to danger of bankruptcy while waiting for the future increase of population and patronage to bring adequate return. This is particularly true of a private company operating a public utility under a limited franchise.

On the other hand the writer would regard as of important consideration, the defects of service resulting from the use of a highly deteriorated physical property which is altogether inadequate to meet the current demands of its patrons, to say nothing of provision for meeting in proper form and with a proper degree of safety and success, the emergency requirements which arise periodically in the operation of every public utility.

The relative hazard in a slow growing but substantial town and that in a rapidly growing and developing city are also matters of consideration. The liability of having to abandon property representing judicious investment in the latter case is much greater than in the preceding case, and greater regard must be given to investments in anticipation of future requirements. In short there are decidedly business considerations as well as technical considerations which must enter into computations of going concern value.

In this connection the writer desires to emphasize the point that equitable net earnings must be dependent upon the characteristics and value of the physical property, and that being the case, there is so intimate a relation between going concern value based upon earnings and value of physical property that some simple rule might be devised by which going concern value can be estimated as a percentage of the value of the physical property with due consideration of the local conditions. Perhaps a rule of this kind might be devised which would bridge over the inconsistencies and inequalities in the present methods of computing going concern value, harmonize extreme partisan views with regard to this element of value, and eliminate the confusion often arising between going concern value and franchise value.

There is probably little doubt but what the views of our courts basing present worth primarily upon the cost of reproduction under existing conditions is decidedly rational and introduces less obscurity and less danger of error in estimating present worth of a public utility than would any method based entirely upon past structural costs.

It is to be hoped that so valuable a paper as that of the author will receive broad and candid discussion.

Mr. James B. McDonough: In your paper on "Going Value," there is one point I do not understand. I refer to your suggestion that the city's option to purchase should be recognized in some way. It is not clear to me how this option can affect the value of the plant. If I have an option to buy a house, my option may be of great value, but I cannot see that that adds to or takes from the value of the house. The value of the option may be great to me because of the bargain that it brings me but it is not clear to me how that value can affect the value of the thing sold under the contract.

Mr. John W. Alvord: On the "option" question, Mr. McDonough's illustration of the house seems to me to be a fair one, but I think he does not follow it clear through to the end of the comparison.

Let us assume that he owns a house which, we will say, is rented, and producing a revenue which would cost a real estate man's time, fee and advertising to reproduce. Let us assume that I hold an option to buy his house at the cost of the duplication of the physical property plus the cost of establishing the income, and that this option holds for the end of say, every two years, or some other like period. For the purpose of making the illustration parallel, let it be assumed that no other house is immediately available, and if it is required that such a house be had, his house must be purchased or a duplicate of it built. Now let us suppose that John Doe wants to buy his house, having no option but having the alternative if he will not sell to him, of building a duplicate house of his own, but of course losing the rental *while he is building.*

Now is it not plain that if I should exercise my option I do not have to wait to build or lose any rental while building, therefore I could not be made to pay more for his house on a duplicate basis, than the duplication of its physical value plus the cost of duplicating its income, because my option entitles me to step into the enjoyment of his property and rental at a specific time, without having to face the certainty of losing rental while building. John Doe on the other hand, not having any such option, desiring to own Mr. McDonough's property, finds that it is worth not only what it costs to duplicate it, including the income, but also something for the advantage that he possesses by reason of the fact that Mr. McDonough's property is *already built* and he may with propriety ask Mr. Doe something for the advantage he has over Mr. Doe in the losses of rental he would sustain *while building.* He properly reasons therefore, that he can afford to pay Mr. McDonough, perhaps not all, but the greater part of such losses of revenue while he would be building, while I, holding an option and exercising it, do not have to consider the possibility at all.

It seems to me that this is a very good illustration of what I am suggesting in the ordinary water works valuation, that is, to recognize the option which the city is exercising when it takes a water company's plant in conformity with its contractual rights, because if the water company is selling to an outside party or selling to the city on an informal negotiation at some other period than the option date, or is being valued for rate making purpose, it may have and will have a value greater than the cost of duplicating the physical property and income by a part at least of what would be lost in net rentals during the construction of an alternative plant. Necessarily, it would not be all of these net revenues, as that would not produce a "willing buyer," the alternative of building a duplicate plant being equally attractive to the proposed purchaser.

Mr. Benezette Williams (by letter): It is the opinion of the writer that Mr. Alvord's paper is a most valuable contribution to the cause of rational proceedings in the valuation of *public utilities*, and that his insistence upon the need of sound and clear conceptions of the principles which underlie *public utility values*, is not the least valuable part of his contribution.

In this connection, special emphasis should be placed upon the fact that it is *public utilities* which are under consideration, because one of the most fruitful causes of confusion was, and is still to a considerable extent, the failure to distinguish between a plant serving the public exclusively under a franchise granting special privileges, in which there can be no competition, and a manufacturing plant that has no special privileges, and that supplies needs of the people in some line where private competition has free play, and into which the use of public property, such as streets and commons, does not enter.

It may be said that primarily, all values that attach to public utilities grow out of the physical plant and its earnings. *Physical or structural value* can only be determined on the basis of original cost, that is, by the actual, legitimate investment in the utility, or upon the reproduction structural cost, made as of some particular time, with such depreciation as the conditions warrant.

The older conception of what are now known as public service corporations, and public utilities, which was based upon the theory that a company operating under a special grant from some legislative authority was its own master, and not subject to rate regulation or control, is fast giving place to a newer and sounder one. Franchises, or grants conferring special privileges, were and still are, so far as they extend to definite matters, considered property which may have value or not, depending upon whether the business authorized is profitable or unprofitable.

The modern conception is that its sole function is to serve the public and that it is entitled to a revenue sufficient for operation, maintenance, renewals and an adequate return on the capital invested, which carries with it governmental regulation of rates and control as to the character of the service rendered. The franchise under which it operates being indeterminate, and hence not property in the older meaning of the term.

If the modern conception had even partially prevailed a generation ago, and a joint responsibility had been established between the public and private agencies that brought public utilities into being, the franchises providing that at the expiration of the contracts the utilities should be taken over by the public authorities at a price equal to the actual amount of the investment without depreciation, or that the franchise should be renewed, the complications now experienced in the valuation of such utilities would scarcely have arisen. If this had been done, courts would not have rendered decisions insisting that the rates charged by public service corporations must be reasonable, but giving us no clue as to how the reasonableness of rates can be determined.

Nor would they have traversed a circle, first making the value of public utilities dependent upon rates of income, and second, making the rates dependent upon the value of the utilities.

On the other hand, they would have held that any scale of rates, equitably distributed, that is necessary to secure good service is reasonable. It would have been held that proper service is essential and paramount and that it must be paid for, whatever its necessary cost, or that if the necessary cost could not be borne by the people of the community served, that they should go without such service until it should be borne.

The failure to do this has forced the adoption of the only alternative, where no franchise value exists, viz: the present reproduction cost of the structural property with depreciation and the value of the potential earning power as the ultimate basis of value.

This situation was presented in the Kansas City Water Works case, where the franchise no longer existed, and the company was under contract to sell and the city to buy or to renew the contract.

Out of this case thus presented, grew the conception of the element now known as "going value," though then referred to by the Court as the "additional value created by the fact of many connections with buildings, with actual supply and actual earnings." The value of the property, it was held, was "not merely the value of a system which might be made to earn, but that of a system which does earn."

The term "going value" does not appear to have been used by the Court or anyone connected with the case. The Court referred to the system as a "living and going business," and at least one of the attorneys for the company in his brief, speaks of it as a "going concern."

Judge Brewer's decision in this case was made in July, 1894, and in January, 1895, the commissioners appointed to determine the value of the property of the Newburyport Water Company, reported to the Court that they find that the plant was a "going concern" and that it had a greater value than if it had not been in operation, and that its value was enhanced $40,000 by reason thereof. The Supreme Court of Massachusetts sustained this finding in a decision rendered in June, 1907. The term "going value" does not seem to have been used in this case.

In April, 1897, Mr. Wynkoop Kiersted presented to the American Society of Civil Engineers an able and exhaustive paper on the "Valuation of Water Works Property," which was extensively discussed by twenty members of the Society. In all the one hundred pages of Mr. Kiersted's paper and the discussion, the words "going value" are not used, nor has the writer been able to find any expression indicating that the conception of "going value" as set forth in Mr. Alvord's paper, existed in the minds of any of those who participated in the discussion.

The author of the paper, Mr. Kiersted, contends for an appraisement of the "value of a plant and its business as a whole upon a fair and equitable basis," but the method favored by him though it made the business considerations of equal importance with the present physical value, anticipated that the business element was to be determined by some method of capitalizing net earnings, and modifying the same by engineering considerations. In summing up, after considering all the discussions of his paper, Mr. Kiersted holds to the view that "still there remains very substantial ground to believe that net earnings constitute the true basis of appraisement when proper deductions are made from the valuation so determined in accordance with the character of service rendered and the physical condition of the property."

DUBUQUE APPRAISEMENT.

The Board of Arbitrators in the Dubuque case, chosen early in April, 1899, consisted of five members, the writer being the only one of the five who had had an engineering training, or who had had any experience in the valuation of public utilities.

Mr. Kiersted's paper had engaged his earnest attention, and the principles of the Kansas City decision were understood in a general way, but not with sufficient thoroughness to base an important valuation upon. Realizing the insufficiency of his grasp of the principles underlying the Kansas City decision, the writer obtained the full record in the case from the clerk of the Court at St. Louis, upon which the case had been appealed from the District Court to the United States Circuit Court of Appeals, with the briefs of the attorneys accompanying the appeal, and made a careful study of the same, abstracting the most important matters contained in the record, and in the attorney's briefs.

Growing out of this he made an application of the principles of that decision to the Dubuque plant which is set forth in an opinion filed by him and which was printed in the "Proceedings and Findings of the Board of Arbitration." In this opinion a conception of "going value" was promulgated and the principles and method which it was believed should be followed in determining it, were set forth in detail.

For the sake of historical accuracy, in tracing the step-by-step development of the conception of "going value," the writer believes that the publication of portions of the opinion referred to, and a portion of one filed in the same case by John N. Baldwin, a very able attorney of Council Bluffs, who as one of the board of arbitration was intimately associated with the writer at that time, will be of interest. These extracts are hence submitted as an appendix, which by way of reference, is necessary to this discussion.

RETROSPECTIVE REVIEW OF THE DUBUQUE CASE.

In the ten years that have intervened since the writer endeavored to make clear the conception of going value, embodied in the Dubuque opinion, and since drawing the first diagram by the aid of which computations for going value were made, the method there outlined has been used in numerous cases by himself and others.

At that time the computation was, of necessity, based entirely upon the record made by the Dubuque plant during its operation, but the accumulated data since obtained from the operation of other plants, serves to establish the correctness of the general method then outlined upon solid grounds. Such being the case it is not surprising that there were oversights made at Dubuque and that additions to, and modification of the elements entering into the computations should be made. Ten years' experience has led to the following changes in the table for the computation of going value, as used at Dubuque, given in the appendix.

1. On the debit side should be entered the difference of operating expenses from the beginning of the period of construction to the time of equal revenue;

2. Interest on the original or operating plant for the construction period of the substitute plant.

3. A depreciation or renewal fund for the operating plant covering the construction period of the substitute plant.

A complete statement of all the elements required to compute going value, are as follows:

Credits.

1. Estimated domestic earnings for original plant;
2. Hydrant rental during the construction period;

Debits.

1. Estimated domestic earning of substitute plant;
2. Difference of operating expenses;
3. Interest on the original plant for the construction period;
4. Depreciation or renewal fund for the original plant for construction period.

The annual going value obtained from these elements should be reduced to present worth on the basis of compound interest, instead of simple interest, and the per cent used should be the highest allowable as income on capital invested in public utilities. This tends to conservatism.

The writer is unable to agree with the views taken by Mr. Alvord in his paper, regarding some of these elements.

Interest.

The author's treatment of the interest question during the construction period, in the main agrees with correct practice. In the appraisement of an existing plant, interest during its construction should always be made a part of its cost, that is of the investment, and in estimating the cost of a proposed new plant, the same course should be followed.

But during the period allowed for the construction of the hypothetical plant under consideration, the original plant, or the one being valued, is in operation, and the capital which it represents is drawing interest as an investment. This interest should enter into going value computations as it is wholly unlike the interest which accrues during the construction of the plant itself and which has become a part of its capital.

There is nothing analogous to interest on investment running against the hypothetical plant during the period of its construction. All interest is being merged in its capital, and appears as an investment as stated. The plant is not in operation and the investors are drawing no returns. There is hence no interest to stand against it that affects going value. At the close of the construction period of the hypothetical plant, the investment in each plant is equal and the interest thereafter should be neglected.

Hence the author is right that proper practice excludes interest during the construction of each plant from the going value computation, but the interest on the capital of the operating plant during the construction period of the hypothetical plant, should not be excluded, but should appear as a debit in the going value computation.

Depreciation.

With the proper lives and ages assigned, the annual depreciation fund will be the same for each plant, and as depreciation runs on the going plant for the period of construction, and does not appear for the hypothetical plant until it has gone into operation, depreciation certainly should be entered on the debit side for the construction period. After the construction period, depreciation being equal for each plant, it can be ignored.

Public Income.

Hydrant rental, is clearly a credit during the construction period. The going plant is furnishing fire protection for this time, but the other one is not. By the hypothesis, following the construction period the plant will have equal efficiency for the extinguishment of fires, and hydrant rental should hence be ignored thereafter.

Construction Period.

That the going value runs during the hypothetical construction period must be apparent; otherwise, it could not run through any period. The comparison must be between a going plant that never ceases operation, and hence has continuous earning, and a hypothetical one which must have time to be built, as well as time to acquire business. Requisite time for building is just as essential as the requisite time for acquiring business. The holding of any court that the construction period should be ignored because it does not cause money to be necessarily expended by the starting plant can only be due to a misconception of what going value is, and of what it is not.

What is Going Value?

This brings us to the fundamental question, What is going value? And how should it be defined?

The definition of going value given by the author that it is "the value of a created income," is an admirable one, which being the case precludes the idea that "*it is the cost of reproducing a given income.*"

In the conception of the writer the two statements are incompatible with one another. It is impossible to see how the *cost* of creating, or reproducing a given income, can measure its value. Though a fundamental error it is not uncommon to conceive of going value as the cost of building up the business of the public utility, and that it is to be measured by direct outlays made in so doing, and by the interest paid out while it is being done.

Some have advocated measuring going value by the deficit which a plant may have suffered over a term of years, without considering that you cannot create value by a deficit. That the cost of producing a given income, or revenue cannot be a measure of its value, after it is produced, becomes apparent when we consider that any given revenue must be expressed in dollars, as say, $10,000. Should it cost $20,000 to produce $10,000 of revenue, this fact would not turn $10,000 into $20,000.

On the same principle, going value cannot be measured by the expenditure necessary to build up a given business during the years that are passed, but it may, and must be measured by the difference between the revenue which a going plant will produce, and that which a substitute plant can produce in the future.

The diagrams and tables of the going value elements which the author uses to compute the amount of going value are all drawn, and arranged, by setting the earning of the going plant as modified by operating expenses, against the estimated earnings of the hypothetical plant modified in the same manner, and the difference of these he properly calls going value. How then can we conceive of going value being the cost of reproducing a given income, when the author's practice is to the contrary? Either the method of computing going value must be abandoned or the author's conception of going value must be amended, practice should conform to theory.

Mr. Leonard Metcalf in his paper on "Water Works Valuation, etc." presented at the meeting of the American Society of Civil Engineers, December, 1908, falls into the same error.

He says "going concern value may be defined as the cost of establishing , up to the level of the net income of the old plant, at the date of taking, the business of a similar new plant; or, to put the same thing in another way, it is the measure of the greater value (at the date of taking), of an old established plant over a similar new plant complete and ready for operation upon the date of taking."

These two definitions seem antagonistic. The cost spoken of in the first one, cannot be the greater value of the old established plant spoken of in the second one. How is one to know that there is a greater value in the business of the old plant without finding the difference between the results of operating each plant separately during the period of comparison? Why bring in "*a similar new plant*" if not for the purpose of comparing its predicated operations with the operations of the original plant.

If Mr. Metcalf is right that the "established business" element of value "depends directly upon the net income or earning capacity of the works at the date of taking," and if the "similar new plant" has no bearing thereon, it is hard to tell the function of the latter.

Mr. Metcalf's second definition would be correct, in the understanding of the writer, if he had not assumed that the new plant should be complete and ready for operation upon the date of taking the old one. Why, if this assumption is permissible, should he not assume that the new plant is not only complete and ready for operation, but that it has acquired the full business of the old one at the time of taking? One assumption is no more violent than the other, and by making the assumption complete, going value would be eliminated entirely.

Other Definitions of Going Value.

In the extracts from the Dubuque opinion in the appendix will be found, so far as the writer knows, the first effort to give a comprehensive definition to going value.

Since that definition was given, the writer has frequently found it desirable to formulate other and perhaps briefer definitions, for the purpose of appealing to other minds, from varying standpoints.

One such definition formulated by the writer is:

> Going value is the potential business value, the amount of which must be determined by the net income which a plant in operation can produce, in excess of that which a substitute plant of like character can produce, the construction of which is begun at the time of valuation; the annual excess income being reduced to present worth.

In the farther effort to make clear to other minds, that going value as conceived of and defined is not the same as franchise value, and that it of necessity attaches to all public utilities plants, whether there is a franchise to be valued or not, the following more comprehensive statement of the writer's is presented:

> Going value is inherent in the plant, and is a part of it just as truly as the cost of machinery and pipes is a part.
>
> While it has no existence without earnings, it is not necessary that the earnings shall equal expenses to give it a status. In other words, a plant may be losing money and still have a going value. This apparent paradox arises from the fact that it is the difference of earnings between the plant being valued and a hypothetical substitute plant, supposed to start with the same surroundings and conditions, under which the plant to be valued operates, but with the field clear and unoccupied, which constitutes going value. As long as the earnings of the substitute plant are less than those of the plant under valuation, the latter will have a going value. When the acquired business of the two plants becomes equal, going value ceases. Thus, while going value on one side depends upon the earnings of the plant being valued, it is dependent on the other side upon the rate at which it would be possible for a new, or substitute plant, to acquire business in the same, though a clear field, beginning with the time the valuation takes place. In other words, it is the difference in earnings of the plant in question, and the probable earnings of a substitute plant, with all its business to acquire, between the time of valuation and that time in the future when their revenues are supposed to become equal, that constitutes and measures going value.
>
> Franchise value is distinct from going value. It is dependent upon the right to operate or upon the right to the proceeds of operation, and upon profits.

Though going value presupposes a continuation of operation, it is no more dependent upon such continuation than is the value of the physical plant.

When a plant ceases to operate it becomes junk, and its structural value dies with its going value. They live and die together.

Though the present owner of a plant may lose his right to operate, the purchaser who has the right will profit from the accrued business as surely as from the business acquired under his own ownership. The accrued business is the creation of the former owner, and is vested in the plant at the time of transfer, and that portion of this accrued business, which is in excess of what the purchaser can create, with the same or a like plant starting without any business, is the going value. The seller has as much right to this, though the franchise may be dead to him, as he has to the physical value. There is no more justification in taking it from him without compensation than in taking the plant itself without paying therefor.

In case a purchaser takes over a plant under a limited franchise running to himself, having paid therefor the physical value plus the going value, and continues to operate it to the end of the franchise period, the total earnings growing out of the accrued business, and that which he may acquire, after paying interest, operation expenses, and depreciation, less the going value, in other words the profits, is the value of the franchise.

On the expiration of the franchise period, that portion of the total business which has accrued which would be in excess of what a second purchaser can create starting new with a like plant, is again the going value, which, if the plant and business have grown, will be greater than before.

In this case the value of the franchise accrues to the owner under his own operation, but when the owner is forced to sell, having a right to the value of the franchise for a term of years beyond the time of sale, he becomes the beneficiary of the franchise without the right to operate.

It is thus seen that cases may arise where the seller is entitled to a price much in excess of the structural value of the plant, without having a right to operate. He may have the right to the proceeds of a franchise, but he must part with it for a consideration, and this consideration is due because of what the plant will earn after it passes out of his hands. The owner's right to this franchise value cannot be inhibited, because it is a draft upon the future, neither can going value be consistently inhibited, because it must be determined by what the plant can yield in the future as a result of the business which is the creation of the past.

In the first case the profits of future earnings are realized without a continuation of operation in the hands of the beneficiary, while in the latter case the beneficiary merely recovers for the most part his past outlays, made to create business for the future. These cases are alike in another respect; in each the owner is forced to sell and the franchise is dead to him.

It is obvious from the foregoing discussion, that in making an appraisement of the property of a public service corporation, there is a fundamental difference between an allowance for going value, and an allowance for franchise value, if either or both should be made. The first is what is shown to be due in a general rounding up of past accounts, a closing of the books to date, while the second is a draft on the future, made wholly in anticipation of subsequent profits, the first involves the outcome of operations that are past, while the second involves earnings to accrue as the outcome of operations in the future. Going value is always to be considered an element for valuation, while the consideration of franchise value depends upon the character of the contract.

It is to be observed that the foregoing statement is predicated upon the modern conception of a public utility, that it has a continuing existence, and never ceases to operate. It may change hands at stated periods, but it is always the same entity, carrying with it at each and any change the reproduction constructural value, and the accumulated business value. They cannot be separated. Franchise value may be wiped out by a word in the grant, or by fixing rates so there are no profits, all the earnings being absorbed in fixed charges, operation and maintenance, but the going value remains. It may fluctuate in amount owing to varying conditions under which the plant operates, but it is always there and can be determined as the writer believes, with an approximation to accuracy that will compare favorably to estimates of values for the physical plant. The writer has not infrequently seen two estimates for the physical value of a plant which varied over 100 per cent.

RELIABILITY OF GOING VALUE ESTIMATES.

It is easy to agree with the author that estimates of going value may be overworked, but it is just as true that they may be easily underworked. The same can be truthfully said of the reproduction cost of the structural plant.

One can as readily go astray in fixing the life of a plant, or of a specific part thereof, upon which depreciation is based, as in fixing the time when a going plant and a hypothetical plant will attain equal revenues.

To one familiar with construction, the period necessary therefor can be much more accurately determined in advance than can the life, or even the cost of many of the parts composing the plant. Life must be determined by experience with the plant under consideration, and by like experiences with similar plants elsewhere.

The assignment of future usefulness, of a given number of years to any part of a plant, may be just as conjectural as any of the determinations and assumptions, required in the process of computing going value.

The author gives a number of cases in the computation of going value, some of the elements for which differ widely from the writer's experiences.

Diagram No. 2 is for a city of 25,802 inhabitants, the domestic revenue of the plant is about $68,000, and the going value $68,614. To reach this level the hypothetical plant must gain a domestic revenue of $35,000 in one year, which is at the rate of one dollar per capita in less than nine months.

Diagram No. 6, population 6,072. Domestic revenue $11,500, going value $8,961, giving one dollar per capita acquired by the hypothetical plant in one year.

Diagram No. 14, population 36,252. Domestic revenue $76,000. Going value $149,829, one dollar per capita acquired by the hypothetical plant in less than one year.

A comparison of the time allowed by the author in the foregoing cases for the hypothetical plants to acquire a revenue of one dollar per capita, never more than one year, with the time required by experience in actual operation for the eleven cities given below, does not indicate much danger of extravagance in computing going value.

Table showing the time required for Water Work plants in the eleven cities given, to acquire one dollar per capita of domestic revenue.

	Domestic revenue in dollars and population.	Years to acquire one dollar per capita.
Appleton, Wis.	16,700	21
Eau Claire, Wis.	18,000	15
Sheboygan, Wis.	20,000	6
Galena, Kansas	4,700	8
Hornelsville, N. Y.	11,000	8
Flint, Michigan	10,200	8
Dubuque, Iowa	36,300	29
Beloit, Wis.	9,000	12
Ludington, Michigan	8,000	10
Warren, Ohio	7,200	7.5
Salina, Kansas	5,500	12

It should be said with reference to Dubuque, that for the first eighteen years of the 29 year period the water supply was inadequate in quantity, and a large part of the city was not covered by the distribution mains. At least $22,000 of the $36,300 revenue was acquired in eleven years immediately preceding the year 1900, and after a general increase in the water supply had been made.

A separate analysis of the various elements that enter into a going value computation will bring to light the liability, if any, of overestimating, better than can be done any other way.

Credits

1. The estimate for domestic earnings of the going plant, for the period of attaining equal revenue, with the population of the city and the business growth of the plant for the past at hand, is a simple matter, and even a considerable variation from what will be realized affects the computations but slightly. Such an estimate is far more certain than any determination of the life of the physical plant can be.

2. Hydrant rental admits of no variation. It should be taken at the contract amount in force at the time of valuation.

Debits

1. Estimated domestic earnings of the substitute plant as usually determined, is more uncertain than any other element, and it is also the one which affects results the most profoundly. With the going plant the estimated earnings start with a known amount, and with the trend generally established by many years of past operation, and the city's growth in population. With the substitute plant initial earnings must be fixed in consideration of the probabilities in the case as indicated by the rapidity with which the old plant gained business, the character of the business, and with reference to the known experience of plants in other cities.

Though this element is the most influential, it is perhaps less likely to be estimated so as to produce an effect giving too large a going value determination than any other.

The reason for this will be understood by noting the time that it has taken water works plants to acquire one dollar of revenue per capita, as shown in the preceding table. Of the eleven cities listed, there are only two that have taken less than eight years to do so. It is rare that the revenue curve for a substitute plant is so drawn that it does not credit it with acquiring one dollar per capita in less than half of the time that was required for the going plant, and it is seldom that the period for acquiring equal revenue extends beyond eight or nine years, which is less than the time required by the going plant to acquire one dollar per capita.

As has been pointed out, the author has drawn the revenue curve for his substitute plants so that none of them are given more than one year for acquiring one dollar per capita.

2. Difference of operating expenses is important but much less so than the revenue of the substitute plant. In estimating it, one is more likely to make the difference too great rather than too small. The greater the difference, the less the going value, so that the chances are in favor of lower determination of going value, so far as the influence of this element extends.

3. Interest on the original plant for the construction period cannot go astray if the proper rate of interest is used, because the total interest debited will be proportioned to the length of the period.

4. The total depreciation fund will be proportioned to the construction period. The annual fund itself is determined in estimating the value of the physical structure, and if in error, it will affect the structural value to an extent as much greater than it affects the going value, as the unexpired life period of the going plant exceeds the construction period of the hypothetical plant.

The writer is convinced that the method of computing going value under consideration, when properly applied, gives results as to accuracy and reliability, that compare favorably with estimates for the reproduction structural value of the plant, and in the light of ten years' experience, during which time he has applied the method to numerous water works plants, and to a limited extent to gas and electrical plants, he believes that the going value determination is far less likely to exceed the true amount than the reproduction structural value.

Extravagant estimates on this line, as well as along all lines, are, of course, to be avoided.

The elemental values that enter into the total value of a plant should each stand on its merits, and if any modification is deemed advisable, it should be made in the general round up.

The writer has advocated this doctrine, in the valuation of public utilities for many years.

In an appraisement made nine years ago, where there was a question of water rights involved, in addition to the usual questions, it became evident that a general summary of the individual elements of value, each determined on its own merits, was greater than could be properly taken, as the value of the utility under the conditions as they existed.

The amount determined upon as the proper valuation was about 21 per cent less than the sum of all the elements of value. In reporting upon this fact, it was stated that the sum of the elements amounted to more than the utility was believed to be worth, considering the prospect of the city's growth, the condition of the distribution system, and the earning power of the plant, and particularly in view of the fact that about $100,000 should be expended upon the plant in the near future.

As stated in the report: "This scaling down does not imply that the methods followed in arriving at the individual elements are incorrect, or that the amounts found are excessive."

Also "From the foregoing statement of the case it will be seen that the proper appraisement of a water works plant consists of something more than the mere determination of the value and cost of the elements entering into such appraisement. All the physical property, the rights and franchises belonging to a water works company, must be considered in relation to the use to which they may be put; that is, to their environment. The failure to give proper weight to such elements in relation to these things often leads to erroneous results."

Reserved Right to Purchase

The author suggests one other consideration which may be used to modify going value, viz., the right often reserved by cities to purchase the plant at stated intervals, and that this right has a value. This suggestion brings us around to the starting point, the Kansas City case. There the city not only had the right to buy but it was obligated to buy. By Judge

Brewer's opinion this right was sufficiently important to eliminate all franchise value, but it had no influence on going value. The Kansas City case must be wiped out before the author's suggestion can be properly followed.

APPENDIX

Extract from the Opinion of John N. Baldwin, In the Dubuque Water Works Appraisment.

VALUATION OF THE OLD WORKS AS A "GOING CONCERN."

I have referred to the rule which fixes the allowance of the additional value over and above the cost of reproduction of the plant as a "going concern." There is no question about the rule, but there is always difficulty in making its application.

All the parties to this controversy concede that there is a value, some value at least, to be put upon the old property for this feature of its worth.

* * * *

While the rule and the reasons for the rule are easily understood and appreciated from either a business, a professional or a legal point of view,. the application of the rule is a difficult task. It involves the investigation of these matters from an engineering standpoint. I confess to both a lack of information and of thought upon this subject until I had heard this testimony. Since that time I have studied the views of the different experts and the elements that they have taken into consideration in forming a valuation. I have also studied the analysis of these factors made by my associate, Mr. Williams. It seems to me that this analysis is correct, and I believe that it will also impress any one who will investigate and study it in the same way, and as I believe it is the correct opinion I adopt the same and have considered it in making up my judgment as to the value of this property. This statement is so satisfactory, so cogent in reason and so unanswerable in logic that I most heartily approve of the same and adopt it as a part of my opinion in this case.

It will be observed that no fact or factor enters into the opinion of Mr. Williams that is not found in this record. The difference in the results he obtains and those of the other experts is entirely due to the method of assignment and arrangement of the same facts and factors.

I find the "going value" of this plant to be $147,218.00.

Extracts from the Opinion of Benezette Williams.

(3) "GOING VALUE."

This subject presents a problem wholly different from the problems met under the headings 1 and 2, and the methods to be pursued in arriving at what we believe is, and should be, the correct amount to be allowed for "going value" is of an entirely different character.

The engineers who testified to the value of the plant estimated "going value" as follows:

John W. Alvord	$151,330.00
John W. Hill	106,000.00
J. T. Fanning	137,296.00
D. W. Mead	144,600.00
G. H. Benzenberg	131,138.00
Wynkoop Kiersted and Chas. P. Chase, for the city	62,718.00
Samuel Artingstall and W. S. MacHarg, for the city	49,500.00

It was early realized in the appraisement of water works plants, where the franchise had ceased, or where it was provided in the contract that the franchise should not be valued, that the problem of arriving at an appraisement which should be just to both parties, in view of the peculiar relations which water works companies hold to city corporations, was a difficult one.

To base a valuation upon the cost of construction was unsafe and was found inadmissable, at least in a majority of cases, both because present value cannot be very well determined from cost of construction, especially where the construction has run over a long term of years, and also because certain portions of plants are found to be, in very many instances, entirely abandoned, or rendered useless for the present and future, because of deterioration, or because of being superseded by better appliances.

Neither was the method of valuation by means of capitalizing the net earnings deemed admissible, both because it partook of the nature of valuing the franchise, and because it gives widely varying results, when applied to a plant at different periods of its existence.

The only method left seemed to be that of the cost of reproducing the useful portions of the plant, less the estimated deterioration due to wear and tear, and decay. It was soon realized that estimates confined to the cost of reproduction could not and did not, give a true value of the plant, and that the application of such a method would work great injustice to the owners of the plant, if rigidly made.

In the case of the National Water Works Company of New York vs. Kansas City, in the Circuit Court of the United States for the Western District of Missouri, and which was appealed to the U. S. Circuit Court of Appeals, Eighth Circuit, (to be found in U. S. Fed. Rep., 62,853) the question of the value which attaches to a water works plant because of its being a "going concern," in use, and earning, was brought to a clear-cut issue, and decided as being properly a part of the value of the plant, which should be added to the cost of reproduction.

The Kansas City case is of special value in this one, because it presents the findings of two courts where the same issues had been raised that were raised here, and under almost exactly parallel circumstances, so far as relates to the application of the principles involved. That is, in the Kansas City case, the works had been in operation twenty years, and by the terms of the contract as construed by the court, the city was compelled to purchase the works or renew the franchise for twenty years more.

In the Dubuque case, the works have been in operation something more than twenty years, and under this arbitration proceeding, if a price had been fixed, the city would either have had to take the works as valued by the Board of Arbitration, or leave the franchise in force until its expiration, about twenty-two years hence.

In the Kansas City case the city contended for a valuation which should be less than the mere cost of reproduction reduced by ordinary depreciation, it contended that the valuation should be still further reduced by reason of any faults of construction or incapacity. In opposition to this, the company contended that the works should be considered as a whole, not only the plant, but the business which the plant was doing; in other words that it should be considered as a property in operation, and with a given earning power—that is, a "going concern," and that in such condition it was worth much more than the mere cost of reproduction.

In this contention, the company was fully supported by the Court of Appeals. The place where the company failed, was in not presenting to the court some way of arriving at this operating, or "going" value, which struck the court as being consistent with the fact that the franchise value of the works could not be considered.

It undertook to determine the value of the whole property by a capitalization of the net earnings, and while, as was clearly shown by Mr. Gardiner Lathrop, one of the attorneys for the company, this method of valuation did not give the full value of the franchise for a succeeding period of twenty years, still they were unable to convince the court that such a method did not include franchise value.

The court held that the mere cost of reproducing the plant would not be a fair valuation "because it does not take into account the value which flows from the established connections between the pipes and the buildings of the city." And that "the cost of reproduction does not give the value of the property as it is today."

But though it thus clearly recognizes the existence of a value in excess of the cost of reproduction, it does not in terms define such value or lay down any general principles by which such value can be determined.

It, however, does establish the principle that in such cases the true valuation consists of two elements: First, the reproduction value, and second, the operating or "going value." Indeed, there is no logical escape from the conclusion that the value of a plant where the franchise is not involved does consist of these two elements. It is futile to attempt to establish a method of valuation which does not take into consideration the present reproduction value of a plant, and since this reproduction value does not represent the whole value, there must be added to it that increment due to its potential earning power, which has been aptly termed "going value," or "accumulated value."

The first element, the reproduction value, presents something tangible to the ordinary mind. It can be estimated by men familiar with the cost of constructing works. However much they may differ with regard to this cost, and in regard to the deductions which should be made for depreciation, the problem still remains within the domain of the tangible.

The second element, heretofore, has not been clearly defined in the minds of those having to deal with such questions, if we are to judge from the Kansas City case, and the discussion of Mr. Kiersted's paper on Water Works Valuation, published in the December, 1897, number of the Proceedings of the American Society of Civil Engineers.

Generally, when the problem of measuring "going value" has been considered, the matter of interest during construction, and until the earnings of the new works equals the cost of operation, has been suggested as the unit or basis of measurement.

This is well illustrated by Mr. Robert Moore's discussion of Mr. Kiersted's paper. Mr. Moore and Mr. James Andrews, of Pittsburgh, Pa., had been appointed commissioners in the Kansas City case to "Make a personal inspection, examination and reasonable test or tests of the system of water works which supplies the city and adjacent territory with water, and to estimate and fix the value of said works and system as a whole." They had returned to the court an estimate of $2,546,112 as the value of the works, including the Kaw Point pumping station.

In the discussion of Mr. Kiersted's paper, Mr. Moore says:

"The commissioners for the appraisal of the Kansas City Water Works, of whom the writer was one, reached a valuation of $2,546,112 by estimating, as well as they could under the circumstances, the cost of replacing the plant by another in all respects equally as efficient." "As applied to real estate occupied by the works, this estimate gave an amount much greater than first cost. As applied to buildings, pipes and machinery, this method gave an amount which was no doubt much less than first cost. The commissioners, however, took into account the fact that the plant was in actual operation, with an established business and a long list of patrons, and added to the cost of replacement, which included a liberal allowance for contingencies, an allowance for interest on the investment for a time long enough to enable the business to reach the point at which it was found." * * * * "The one thing to be valued was, the property in working order, with the private attachments all made and the body of patrons ready to take water. The value of all this was the amount of money it would have cost the city at the time of the transfer to replace the property in the same condition in which it was actually found."

"The problem of valuation in this and like cases involves therefore, as already intimated, the summations of the following elements:

(1) A valuation of the real estate owned and occupied.

(2) An estimate of the amount of money necessary to replace the plant, including buildings, reservoirs, machinery, pipes, etc., in its present physical condition, exclusive of interest.

(3) The interest on this amount during the time which would ordinarily and reasonably be required for construction.

(4) A further allowance of interest for such additional time as would probably be required to work up the business to the same standard as that found at the time of the transfer."

Here Mr. Moore makes "going value" to consist entirely of the matter of interest upon the money necessary to replace the plant, counted on the investment during the time of construction, and during the time that would be required to work up the business to the standard found at the time of transfer. This method gives no consideration to the accumulated business of the works. It is purely a matter of "interest" on the investment for a certain time, and for such reason cannot and does not represent "going value."

Such an allowance has reference to new works rather than to old; "going value" must attach to the old and not to the new.

Before entering upon an analysis of the evidence relative to "going value", we will consider—

First, and in a more extended form, the underlying principles which justify the addition of such a value to the cost of reproduction.

Second, determine some method, if possible, by which such value can be measured and estimated in a logical and consistent manner, which will be generally applicable in such cases, thereby establishing a standard by which to test the several results obtained by the engineers in this case, as well as to furnish a test for general application.

Third, the definition of "going value."

Principles which justify the addition of "going value" to the cost of reproduction.

The principle established in the case of the National Water Works Company vs. Kansas City, 62 Fed. Rep., 853, and 27 L. R. A. 827, is held to be obligatory in all similar cases.

The court says that it is not satisfied that either the method proposed by the city or that proposed by the company would, under all the circumstances, give "the fair and equitable value." "Capitalization of the earnings will not, because that implies a continuance of earnings, and a continuance of earnings rest upon the franchise to operate the works. The original cost of the construction cannot control, for original cost and present value are not equivalent terms. Nor would the mere cost of reproducing the water works plant be a fair test, because that does not take into consideration the value which flows from the established connection between pipes and the buildings of the city." * * * *

"The fact that it is a system in operation, not only with a capacity to supply the city, but actually supplying many buildings in the city; not only with a capacity to earn, but actually earning, makes it true that a fair and equitable value is something in excess of the cost of reproduction."

The court further says: "That a system without a single connection between the pipes in the streets and the buildings 'would be a dead structure rather than a living and "going" business.' The additional value created by the fact of many connections with buildings, with actual supply and actual earnings, is not represented by the mere cost of making such connections; such connections are not compelled, but depend upon the will of the property owners and are secured only by the efforts upon the part of the owners of the water works and inducements held out therefor."

* * * *

"If it (the city) steps into possession of the property that not only has the ability to earn but is in fact earning, it should pay therefor not only the value of a system which might be made to earn, but that of a system which does earn."

The court further says, taking into consideration all of the transactions between the city and the company, and the connections already made between the pipes and the buildings, that "We have sought to place a value upon the property as it stands."

In the case of the Newburyport Water Company vs. City of Newburyport (47 N. E. Rep., 533) the Supreme Court of Massachusetts refused to open up the judgment of the lower court confirming an allowance of commissioners of $40,000 for "going concern" value, in fixing the value of the Newburyport water plant, which the city had taken from the company.

The conclusions of these courts are believed to be eminently just. In the process of developing a system of water works from the beginning, there is a large expenditure incurred in the effort to get business. The plant is almost universally run at a loss in its earlier stages, and this expense has really been properly considered a part of the investment, because it has been paid out of the earnings of the plant which would otherwise have gone to pay for the use of the capital.

Mr. Kiersted brings out this fact clearly in the course of his paper before referred to. He says: "The cost of a plant is the amount expended in constructing and establishing it." He also shows that there is a risk attending the building of a successful water works plant. That it is impossible to anticipate the direction of the growth and the magnitude of the expansion of the property. That developments of the city create new conditions, which compel the selection of a new source of water supply and the modification of plans which had previously controlled. Such enforced changes, he holds, are often wholly unanticipated and entail heavy expenditures without increasing revenue, and may often require the abandonment of portions of existing works. This hazard, he thinks, should be considered in the valuation of water works property in its entirety.

He says, "Such losses, together with interest paid upon money, expended during the interval of the construction of the works, are considered by the investor as a part of his invested capital, and an item of original cost of construction."

He also concludes that such outlays "Constitute a legitimate expense, which anybody, city, company or individual, building up a business of water purveyor must incur, *and for which there should be, in some manner, a resulting compensation.*"

He holds that "It is clear that the original cost, or the bare cost of duplicating water works property, is not, of itself, the measure of the value of that property. Its present value embraces both the value of the plant and the business resulting from the use of the plant; together they constitute a single commodity, therefore in an appraisement of value of the water works company, it is the commodity which is appraised and not the materials of construction."

These general principles, so well expressed by Mr. Kiersted, are in full harmony with the judgment of the United States Court of Appeals in the Kansas City case, and as is here contended, furnish the underlying principles which justify the addition of a "going value" to the cost of reproduction.

METHOD BY WHICH "GOING VALUE" CAN BE MEASURED AND ESTIMATED.

If, on a given date, a city such as Dubuque should purchase a water works plant already in operation, and earning a large and growing sum, it would, between the date of purchase and any given time in the future, receive the increasing revenue which such works are capable of earning during that period. This revenue would consist not only of that derived from private water takers, but also it would include the hydrant rental value. During this period, it would pay out the interest on the cost of the investment, plus the cost of operation.

If, however, the city, instead of purchasing a plant in operation, with a large revenue, should at the given date of purchase enter upon the construction of an entirely new plant, the city having been without a plant up to the time of purchase, it would, for the period of construction, extending from the beginning of construction to its end, derive no revenue of any kind whatsoever. But beginning with its final installation the plant would have to its credit the same value for hydrant rental that the old plant would have, and would continue the same value to the end of the given period. On the other hand, the revenue from private sources at the time of installation would be nothing, but the revenue from that time to the time when the two plants would have an equal revenue, would constantly and with substantial regularity increase until it attained an amount equal to the revenue of the old plant.

During this period, extending from the beginning of construction till the revenue of the two plants become equal, the maintenance outlay on account of the new plant would consist of interest on the investment during all but a small part of the time. The operating expenses, however, would not begin until the completion of construction and the final installation of the plant, and from that time on to the end of the period, would continue without intermission. The amount of operating expenses after installation would, in respect to the amount of fuel used, be less at the beginning than they would be for the old plant during the corresponding time. There would, however, be during this period when the cost of fuel would be less, a corresponding increase of other expenses due to the matter of obtaining business, which would not belong to an old plant to the same extent. It is therefore believed that after installation the cost of maintenance of the new plant would equal the cost of maintenance of the old plant. This view is strengthened by Mr. Kiersted (Evidence 415), when he says: "The advantage of purchasing an organized property lies in the fact that the purchaser is thereby enabled to carry on the business of water purveyor without the expense attending the early organization and development of the business."

To get the total relative operating value of two such plants from the period of purchase, or the beginning of construction, till the time when their revenues would be equal, we would, dropping those factors which correspond in the two plants, have to consider only the following ones:

On the credit side would be:

(*a*) The earnings from private sources from the old plant during the whole period.

(*b*) The earnings from hydrant rental during the period of construction.

On the debit side would be:

(*a*) Difference in interest paid during the early part of construction.

(*b*) The cost of operating the old plant during the time of construction; and,

(*c*) The revenues derived from the new plant between the time of installation and the end of the period.

If the difference of the sum of the elements on the credit side, and the sum of the elements on the debit side, be taken for corresponding years, and these yearly differences be reduced to their value at the time of purchase, the sum would represent correctly the real value of the old plant, due to its being a plant in operation, over the value of a new plant, the construction of which was entered upon at the date of purchase of the old.

The following is given as a general definition of "Going Value."

"Going value" consists of the element of earning power which a plant possesses, growing out of it having an assured business in excess of what a new plant starting without any business would have, and it is measured by the sum of the yearly amounts of revenue, reduced to present value, which such plant in operation will produce in excess of what new works of a like character can be made to produce, between the time of purchase and that time in the future when the revenue of the two works become equal; proper allowance being made for differences in cost of maintenance."

Though the above statement of what properly constitutes "going value" is believed to be logically correct, it is conceded that there is liable to be much variation in applying the theory practically. There will be differences of opinion as to how long it will take new works, after their installation, to obtain a revenue equal to the revenue which old works would have attained at a given time. There are also other matters about which differences of opinion may obtain, but the fact that such differences may be presented, does not militate against the value of a clear and correct theory of obtaining "going value."

In an appraisement, differences exist about the simplest things entering into such appraisements. This fact, however, does not relieve appraisers of the obligations resting upon them to determine the various elements of value with their best ability, in accordance with the most consistent theory and the best established facts.

* * * * * * * * *

REVISED ESTIMATE OF "GOING VALUE."

In Dubuque the "going value" should be determined by what new works of like capacity would accomplish during the period considered, beginning in a city of the present size, but which had had no water works, and in which all the inhabitants were provided with the usual domestic methods of getting water, compared with what the old works would accomplish during the same period, that has been in operation twenty-eight years. With the new works, the acquirement of new business would be necessarily slow. It would take many years for people to abandon their old methods of supply and adopt the new. This fact is well established by a study of the revenue chart put in evidence by Mr. Alvord. It is also shown by the fact that today in the city of Dubuque, on the lines of the company's plants, not half of the houses take water from the works. The total number of houses on the lines of the pipe as shown by the affidavit of C. B. Burdick, introduced in evidence, is from 4,170 to 4,270, or say 4,200, while the total number of taps given is 1,760, leaving more than half the houses without connections.

Reference to the diagram shows that if a line representing the average domestic consumption of 1889 to 1899 be drawn, it will start in 1889 with earnings of $15,000, and that for the year ending March 1st, 1899, it shows earnings of $35,000, a gain in ten years of $20,000, or $2,000 per annum. This increase of earnings, as is seen, began with the installation of pumping works at Eighth street, and has continued without intermission to the present time. The previous fourteen years from 1875 to 1889 show a total increase of only $5,500 in domestic revenue, or but $393.00 per annum. This is due evidently to the inadequacy of the water supply, which came wholly from the "level," up to 1889. This supply being only 365,000 gallons a day, kept down the domestic service previous to 1889; but beginning with 1889, and especially since the establishment of the Eagle Point pumping station, the supply has been fairly adequate to the demand. The works are being enlarged to supply a greatly increased demand, and it is believed to be a conservative estimate to assume that during the next eight and one-half years following September 1st, 1899, the increase from domestic service will be fully as great as it was during the ten years previous to 1899; that is, $2,000 per annum. This gives total earnings from domestic service for the old works for the year ending March 1st, 1908, of $53,000.

In making this estimate, additional factors are used as follows:

The total time from the date of purchase, September 1, 1899, to March 1st, 1908, is eight and one-half years; two years of which is used in construction. Money is considered to be worth five per cent on water works investments. Hydrant rental for 1899 of $17,000 is assumed to continue through the years of construction —1900 and 1901. The operating expenses for old works during those two years is taken at $22,000 for each year. It is considered that on September 1st, 1901, new works would start with no earnings, and that in six and one-half years ending with March 1st, 1908, they would have earnings at the rate of $54,000 per annum from domestic service. It is also considered that during this period the expense of maintenance, which includes operating expenses and interest, would be equal for reasons hereinbefore stated. It is also considered that during the period of construction there would be a gain of one year's interest by the new works, or say five per cent on $500,000. A tabulation of the estimate which follows shows a total "going value" of $147,218.00, and is assumed to be correct in the determination made by us in this case.

Estimate of Going Value of Dubuque Water Works.

	CREDITS.			DEBITS.						
Year Ending Sept. 1st.	Domestic Earnings, Old Works.	Hydrant Rental, Old Works.	Total Credits.	Domestic Earnings, New Works.	Operating Expenses, Old Works.	Interest on Investment One Year.	Total Debits.	Annual Going Value.	Divisor.	Present Worth Going Value.
1900	$38,000	$17,000	$55,000		$22,000	$25,000	$47,000	$8,000	1.05	$7,620
1901	40,000	17,000	57,000		22,000		22,000	35,000	1.10	31,818
1902	42,000		42,000	$4,154			4,154	37,846	1.15	32,904
1903	44,000		44,000	12,463			12,463	31,537	1.20	26,275
1904	46,000		46,000	20,770			20,770	25,230	1.25	20,184
1905	48,000		48,000	29,078			29,078	18,922	1.30	14,555
1906	50,000		50,000	37,386			37,386	12,614	1.35	9,342
1907	52,000		52,000	45,694			45,694	6,326	1.40	4,520

Total Going Value $147,218

Mr. William H. Bryan (by letter): This paper is a notable contribution to the meagre literature available on appraisals, and is valuable both for the light thrown on an intricate subject, and for the straightforward exposition of the author's views. To present in an equally straightforward manner a somewhat different view, is the object of this discussion.

It is an unfortunate fact that agreement is still far from general among engineers both as to the proper definition of going value, and as to the correct method of fixing its value. This is well illustrated in the author's compilation of twenty valuations, in which it varies all the way from zero to 47 per cent of the physical value of the plant. Even wider ranges would probably be found if all the appraisals in which it has been considered by able engineers of varying viewpoints, could be compiled and compared. In one of the most important appraisals of recent years, in the hands of five of the leading specialists of the country, no two of them agreed as to the method of computation.

We should not lose courage, however, for there is much evidence indicating that substantial progress is being made towards clearer and fairer views. The writer ventures to indulge the hope that it may soon be possible to so handle this matter that the justice and fairness of our methods will be so apparent as to appeal not only to specialists—but to judges and juries and to mayors and boards of aldermen as well. There must surely be a way to so determine going value as to satisfy both seller and purchaser.

Perhaps the clearest official utterances thus far made on this subject are the recent decisions of the State Railway Commission of Wisconsin. In the Cashton Light and Power Company case they said:

> The element of "going value," created by the investments made in developing the business and in addition to the cost of the physical structure, must be taken into consideration in fixing value; although the franchise of a public utility operating under an indeterminate permit has expired upon the exercise by the municipality of its option to purchase, the plant is to be taken over as a going concern, and just compensation must be awarded for the property taken as a living and operating entity, engaged in serving the public, and not as a mere plant without patrons and without privilege or right to operate and to serve the public, and having but a salvage value.

Also in the Antigo water and the Marinette telephone cases:

> The theory of the Wisconsin public utilities law is that rates shall be reasonable and shall be not greater than enough to yield a fair return on the investment. In determining the investment as a preliminary process to the fixing of rates, the commission had to deal with the claims of large "intangible" franchise values as well as "going values" in both the Antigo water case and the Marinette telephone case. Regarding the former the commission holds that if the municipality required the payment of money or its equivalent, or there was necessary legitimate payment made for the franchise, then the sum which may reasonably be said to have been paid for the franchise may be included in the valuation the same as money necessarily invested in the physical property, But the commission refuses to consider the claims of some experts and corporations that franchises for which no money was paid may have "intangible" values which should be considered in the making of rates.
>
> It has been held by experts that "going value" should be allowed as

so much per customer or as a percentage of the receipts, and some have considered it of as great, if not greater, importance than the physical value of the plant. The commission holds that the actual reasonably wise expenditure of money towards getting the business of the plant established may be included in the value to be allowed for the purpose of fixing rates. Since no plant pays at the outset and the first years of operation are almost invariably accompanied by losses or necessary deficits, the commission holds that such losses may be said to represent the cost of securing an established or going business and as such may be included in the value or investment upon which the rates for public service shall be fixed. But the converse of the rule also holds—that is, if a plant has in the past earned more than a reasonable return, possibly through the toleration of excessive rates, the excess over reasonable earnings may under certain conditions be subtracted in determining the present value of the plant. That is, a "going value" may be negative. In the case of the Marinette Telephone Company, for example, the commission found upon its investigation of the financial history of the company, that through a period of recent years the company had been enjoying a sufficiently high rate of return to write off the early deficits in so far as such deficits might be allowed as going value.

It may be noted, in passing, that the now generally accepted view is that the plant value upon which a fair return must be earned is the present cost of duplicating the existing plant (less depreciation) and not its actual original cost. It is not material, therefore, what the original outlay for franchise may have been, but it *is* important to know what moneys—if any—would now have to be expended to secure such a franchise. Neither are past losses or profits conclusive, further than as they throw light upon probable future earnings.

The important facts in the above rulings are that the Wisconsin Commission has officially recognized the propriety of including going value in appraisals, and has pointed out that it should be computed as the sum of two outlays:

1. Moneys spent directly for getting business; and
2. Moneys advanced to cover losses in the earlier years of operation.

These amounts of course are not the sums which the existing plant may actually have expended, but the amounts a plant starting today would probably have to pay to secure sufficient business to make the plant self-supporting.

Having ascertained the present value of the physical plant, the commission considers it proper to add to it these two amounts,—the total being the fair value at which the plant might be sold, or upon which the owners are entitled to earn a fair return.

Assuming the existence of the bare physical plant—without connections or business—what additional outlay would be necessary, under the conditions existing at the time of the appraisal, to bring its income up to a point where its losses would cease, and it would begin to earn a fair return?

Legitimate expenditures to build up business would cover such items as advertising, circulars, solicitors, special rates, or even free water, for limited periods, free connections, plumbing at or below cost, etc. Not infrequently solicitors are paid a fixed sum per contract brought in. Such outlays would unquestionably hasten the attachment of services and thus shorten the unproductive period. It is proper to take into consideration the present-day general knowledge and appreciation of the advantages of water under pressure, and the fact that it is now a necessity in manufacturing, commercial and domestic life. In any modern city the demand would be immediate and extensive, and the rapidity of securing business would—in most cases—be limited only by the ability of the working forces to install the plumbing and make the connections. At starting the plant would have the public revenue from fire hydrants, public buildings, fountains, etc., and soon thereafter the income from a considerable number of private consumers. This would cover a large part of the operating expense—probably half, or more. It then remains for the appraiser to estimate the period within which the necessary volume of business would be connected, and to compute the probable losses up to that time. This is a matter calling for the trained judgment of a skilled observer. It depends upon the size of the city, the character and habits of the people, their wealth, the number of factories, breweries, railroads, etc., and the quality and quantity of other available supplies, such as wells and cisterns—and many other things.

The physical value of the existing plant is ascertained by estimating the cost of a duplicate plant and deducting depreciation, such cost including of course interest, administration, etc., during the construction period. Some engineers—among them the author—hold that as this duplicate plant could not be gotten into actual service for a considerable period, the net earnings of the existing plant during that period are properly a part of going value. The income of the existing plant being limited however to a "fair return," there would be no excess earnings, and therefore nothing to add. From this standpoint the city's right to purchase in no way affects going value.

The probable operating expense of the "starting plant" may be projected into the future with reasonable accuracy. It must of course include not only the ordinary expenditures for labor, fuel, supplies, etc., but also taxes, repairs, administration, interest, and depreciation. The growth of income, however, is not so easily estimated, as it involves both the volume of business, and the rates charged.

Income depends upon rates. A favorable schedule—not necessarily the highest—will shorten the unproductive period, and thus decrease going value. Unwise rates retard growth and increase going value. Attempts to determine going value must therefore presuppose some basis of rates. But rate revision—directly or indirectly—is the purpose of most appraisals. To assume rates as a step towards fixing rates is to reason in a circle. What then shall be done?

Many appraisers assume that existing rates continue. It is argued that they furnish the only definite data available affecting income. To change them would be to enter upon the problematical. But existing rates may be either too high or too low for a fair return.

The tentative or "cut and try" method would seem much preferable. First compute income and then going value, using existing rates. If that income is more than a fair return, repeat the calculations at a lower rate. If insufficient try a higher schedule. Continue these trials until a rate is found which will insure a fair return within a reasonable period. The going value on this schedule would seem to be the proper one.

Going value thus determined is clearly independent of whether the franchise has expired or whether the city has the right to purchase. It enters into the appraised value of the plant, just the same as any physical item—at its cost of reproduction.

It is interesting at this point to note the Wisconsin Commission's conclusion that going value may be negative, when later profits above a fair return have more than wiped out the deficits of the earlier years. Is not this a reasonable consideration for the future? Assuming a rate schedule and growth of business which would make the plant self-sustaining within a reasonable period, the normal continuation of that growth would cause the plant to earn profits which would soon offset the earlier losses, and thus destroy our measure of going value. It would be within the legitimate power of the authorities to so adjust rates as to bring this about.

Turning now to the paper under discussion, we find that the author defines the going value of an existing plant as the cost of reproducing the income of that plant. He fixes its amount by computing the difference between the net results of its operation and the net results of a well conducted "starting plant, through the time necessary to enable the starting plant to be completed and recover an income equal to that of the going plant."

The differences between the author's views, and those now officially promulgated by the Wisconsin Commission—which, by the way, are held by many able engineers—are worthy of serious consideration.

The first difference is one of definition—the author holding that the income, the cost of producing which is to be estimated, is the gross income of the existing plant. The commission's view is that an income sufficient to meet operating expenses is sufficient. Losses having ceased further business is secured without cost. Previous losses may properly be called going value and charged to capital account. A greater income is of no interest or value to the municipality, for rates will at once be readjusted to the "fair return" basis, whether the appraisal is for sale or rate fixing. No city could fairly be asked to pay an inflated "going value" based on an excessive income which it will immediately proceed to reduce. Existing income based on existing rates is therefore valueless for this purpose, and may even be misleading, as producing sometimes more—sometimes less—than a fair return. It would seem that the author himself has sometimes used this method—see his diagram No. 17.

Viewed from this standpoint the financial history of the existing plant has only an indirect interest. It may help us to estimate the cost of operation, and to form some judgment as to the time within which the starting plant will begin to earn a fair return.

The second difference between the author and the commission lies in the method of computation. Nowhere does the author recognize the direct expenditures for getting business already referred to. He compares the existing plant already doing business as a going concern, with a similar "conceptual" plant without business, which would have to be built and put into operation. Meanwhile the business of the existing plant continues its normal growth. He concedes, however, that at some future date the starting plant will acquire an income equal to that to which the existing plant has then grown. The difference in net operating results up to this date comprises—in the author's opinion—the full measure of going value.

Two perplexities here confront us. The existing plant with its prestige of years, its standing in the community, its "going value" if you please— would seem to have a permanent advantage. Having usually twenty or more years the start, ought not its continuing growth, to keep it permanently ahead of the newer plant? And if there is to be forever a difference in their income then the going value thus computed must be infinite.

If, however, the "starting plant" is assumed to grow at so rapid a rate that in a few years its income equals that of the existing plant, why should that rate of growth then suddenly drop to that of the existing plant? Will not the same conditions which have caused its previous rapid growth continue? If they do, thenceforward there would be an excess of income which would soon wipe out the earlier shortages, as has been well pointed out by the Wisconsin Commission.

A system of computing going value whose results may range all the way from zero to infinity, is not pleasant to contemplate. But these difficulties vanish when the "fair return" income—and not the existing income—is taken as the basis.

The author's method might fairly measure the increased worth of the existing system to a private purchaser as compared with a prospective plant without business—assuming a continuance of rates and income. But such assumption cannot be made in the case of municipalities (except where unexpired franchises exist) as the ultimate purpose of practically all investigations of this kind is rate revision. Furthermore, the *cost* of reproduction is the ruling condition—not the value of the thing reproduced, exactly as is the case with a pumping engine, or any other feature of the physical plant.

Many attempts have been made to compute going value along similar lines, although but few have followed the author's exact definitions. In some such comparisons interest and depreciation during the construction period have been assumed equal on the existing and starting plants, while they should not be charged against the starting plant at all. There is no depreciation prior to the start, and interest is always included in the construction account.

This, however, brings up another matter. As the author well says, it is not fair to substitute hindsight for foresight. No designer can foresee all possible contingencies—no engineer is infallible. Mistakes have always been made—and always will be. Boilers, engines, standpipes, buildings, reservoirs, purification systems—even sources of supply have failed, necessitating removal, and in some cases abandonment of entire plants. Sometimes the city has not grown in the direction originally expected. Even the most capable and experienced designers, associated with men of the soundest business judgment, have encountered such disasters. It is a hazard of the business. If a new plant were begun tomorrow either by private parties or the municipality—this risk, in greater or lesser degree, would necessarily inhere in it.

No fair-minded appraiser, however, would include allowance for such mistakes, however unavoidable. The city cannot fairly be asked to purchase at—or pay rates on—values so determined. But does not the fact that the existing plant has—as it were—"sown its wild oats"—has discarded its unwise and useless equipment, and has demonstrated the fitness of its remaining parts—make it of more value than a new plant with that unavoidable experience still to go through?

The writer confesses to some uncertainty as to just where this factor should appear, but that it is an element which should not be overlooked he is certain. For lack of a better place he suggests that it have its weight as one of the "contingencies" in fixing the percentage to be added to the cost of reproduction. In the average case, however, its value would not be large.

What should be the attitude of the conscientious appraiser toward those plants which are losing money? Has such a plant a going value?

This question has been answered in all seriousness in the affirmative. It has been held that an established plant would lose less money than one with its business still being developed. Under the author's method the excess in loss of the "starting" over the existing plant would measure the going value. The Wisconsin Commission plan could not of course be applied, as the continuing losses would make the going value unlimited. Under these circumstances there may be several views:

(1) A study of the situation may show that the normal growth of the business will soon end the losses.

(2) The losses may be decreased—and in due time ended—by some reasonable advance in rates. In both of these cases the Wisconsin rule could safely be applied.

(3) If, however, the situation is such that there appears to be no reasonable way to make the plant earn a fair return, the solution becomes complex.

Such cases unfortunately are not uncommon—particularly in smaller cities, and in undeveloped or boom territory. Sometimes both the city and the owners have been over-sanguine as to the future. Many cities have in times of enthusiasm and prosperity been induced by energetic promoters to enter into contracts for service which have later proved exceedingly unwise for all parties concerned. Business has not developed, nor has the place grown, as anticipated. Important industries may have ceased; opposition towns or railroads may have taken the business away.

While the plant is losing money at the existing rates, it is nearly always true that these rates—both public and private—are a serious strain on the limited resources of the city and its people. No advance is therefore possible—it may even be impossible to maintain existing rates. Not infrequently the expiration of the contract is looked forward to as a date when relief may be expected.

Such contracts are usually for periods of twenty to thirty years. Usually all obligations between the parties end with the expiration of the contract. There seems no escape from the conclusion that the owners of the plant must accept the situation as it then exists. As they would have been entitled to the profits of a successful plant, so also must they accept the losses of the unprofitable one. If the cost of service is beyond its means the city is at liberty to discontinue it. If the contract made no provision for extensions—or if such provisions were illegal—the plant has no right superior to those of the municipality. It is to be presumed that the owners knowingly took the risk of securing ,within the contract period, such returns as were necessary.

This view is of course hard on the invested capital but the law very wisely prohibits municipalities from incurring obligations which may prove onerous to future generations. Posterity should not be made to suffer through the errors of earlier days. In some cases it has been held that owing to the uncertainties attending the situation at the end of the contract, the "fair return" basis entitled the owners to rates which would make the earnings sufficient to retire the entire investment—less scrap value—within the contract period. This interpretation, however, is very rare. It has a counterpart in those states which require the establishment of sinking funds by municipally owned plants to retire the bond issue within a definite period, usually much less than the life of the plant.

The problem then is—not whether a going value should be included in the value of the plant—but to determine a value which the maximum income possible under the existing circumstances will support. In other words, the actual worth of the service to the community fixes a limit to the value of the plant, beyond which no figures however elaborate or logical can go.

Under a strict interpretation of either the Alvord or the Wisconsin theory, the city would be required to purchase the plant at a valuation—or pay rates giving a fair return on a valuation —based on cost of duplication less depreciation plus going value. The latter on account of the slow building up of the business, would be large.

Clearly, however, this would be unfair to the city, as involving prohibitory rates—rates which the public service could not stand, and which would discourage private consumption and prohibit growth, thus minimizing private revenue. The difference could not be made up by increased taxation as this is limited by law.

We may of course take the broad stand that if a city wants water works it must pay the price—they cannot be run as charitable institutions. But there is a limit to the city's ability to pay. Is it not true therefore that the plant in order to continue to serve the community, must be willing to adjust its rates to a basis which the people can pay? Would not any other course necessarily end in forcing the city to discontinue a service beyond its means—a result disastrous to all concerned?

Evidently the construction of a plant at all in such a location was a mistake on both sides. Is it not the clear duty of the appraiser in such cases to eliminate on the one hand every possible element of questionable value, and to get his figures down to bed rock, in the hope of finding a way to meet the exigencies of the situation? And on the other hand to see that the city acts in equal good faith —that it properly appreciates the full value of a good supply, and apportions the maximum amount possible to that service. It is worth remembering that in many cases the lowering of private rates to points originally considered suicidal, has so attracted consumers as to materially increase both gross and net income.

Evidently in such unfortunate cases the situation demands a valuation quite apart from the actual physical plus the going values, however just those values may be in the abstract. Fairness to the municipality is not less essential than fairness to the plant. The courts have decided that while such regulations are intended to be mutually fair, they must in any event be fair to the city.

Clearly such reasoning is only effective when the city is prepared for the alternative of abandoning the service. If it is so situated that it cannot do without the service, then it must find a way to pay a fair return for it. But in no event can the value of such service exceed the cost of getting that service in some other way.

Further perplexities are often found. It has been questioned by many fair-minded men whether the plant after all has any ownership of the business on which going value is based. Should the people pay for what they have themselves furnished? Certainly such value can go no further than the actual cost of reproducing that business.

It will be noticed that both the Alvord and Wisconsin methods give the greatest going value to those plants which have had the longest and hardest struggles to build up their business, while such plants are actually worth the least as commercial propositions. Prosperous plants, with large business quickly established, have the least going value, though far more attractive to the investor. The same is true as regards rates. A high schedule usually means low going value, while low rates increase going value.

With such wide divergences of opinion among thoughtful and fair-minded men, it is not strange that much effort has been devoted to the finding of better and simpler methods. Nor is it strange that despairing of success, shorter methods—less logical perhaps, but giving due recognition to the underlying principle—should find favor. Some of these may be noted:

In one of the most important cases of recent years, in the hands of men of great ability, the results of various methods of computation were all found to be reasonably close to one year's gross revenue, and that sum was finally agreed upon.

In the Staten Island case—see paper by Mr. L. L. Tribus, presented at this meeting—the going value was arbitrarily fixed at $10.00 per service.

In Canada a flat addition of 10 per cent is made to the physical value to cover all the intangible values. See Municipal Acts of Ontario, 3 Ed. VII, Chap. 19, Sec. 566. Sub Section 4, clause (a2), which reads:

> In any arbitration under Clause (*a*) hereof to determine the price to be paid for the works and property of a gas or water company, the arbitrators shall determine the actual value of such works and property having regard to what the same would cost if the works should be then constructed or the property then bought, making a due allowance for deterioration and wear and tear, and making all other proper allowances, but not allowing anything for prospective profits or franchise, and shall increase the amount so ascertained by ten per cent thereof, and such increased amount shall be the amount which the arbitrator or arbitrators shall award as the price to be allowed for the said works and property.

In drawing a new contract at Mexico, Mo., the writer recently adopted a somewhat similar idea, as follows:

> *Purchase by City:* The City shall have the right to acquire by purchase all the property of the Grantee actually used and useful for the convenience of the public, at any time after the expiration of fifteen (15) years from the passage and approval of this ordinance by public vote, upon giving one year's notice to the Grantee, and upon paying therefor in cash the then cost of duplication, less depreciation, of said property, with ten per cent (10 per cent.) additional thereto as compensation for earning power, franchise value, going value, contingencies, and all other intangible values of every nature whatsoever.

The author's concluding remarks indicate a preference for using the actual cost of the existing plant—where it can be ascertained—as the basis of fixing rates, rather than the present cost of reproduction less depreciation, because of the exceeding complexity of the computations. It may be questioned whether many appraisers will follow him here. The idea is fundamental that present values and rates must be based on present-day conditions. Nor is it usually difficult for able, experienced and fair-minded appraisers to agree with reasonable closeness on physical values.

When the intangible values are taken up the situation—as has been shown—is far different. Here if anywhere simple and direct methods—appealing more strongly to the average man's ideas of fairness—are needed. And from this standpoint the simple methods used above are not without merit.

The writer finds difficulty in following the author in another matter, that of computing the cost of reproducing the existing plant. The author seems to justify including all worn-out or discarded parts. He states that the computations must be based on the identical plant under consideration, and it must be assumed to encounter all the difficulties which the original plant met with. (Paragraphs 3, 4 and 5 under "Physical Value.")

The reproduction theory assumes that the existing plant in whole or in part is suited to the present-day needs of the community. The value of a service cannot exceed the cost to the city of serving itself, plus a reasonable profit commensurate with the responsibility and risk involved. In so far therefore as the plant as it stands is well adapted to that service it is entitled to a fair return. But worn-out and discarded parts have no part in present performance, and should have been covered by past earnings. They represent no present value, however necessary they may have been earlier. Nor can present values be saddled with errors of judgment resulting in unwise expenditures, unless it is clear that these or similar outlays would accompany the duplication of the plant today. The writer would, as already stated, favor some allowance among "contingencies" to cover such risks of design and construction as unavoidably attend such enterprises.

Nor need the plant to be duplicated be an exact counterpart of the existing plant, except so far as it is adapted to existing conditions. Real estate, buildings, machinery, pipe lines, material and supplies—beyond the present or reasonably early needs of the system—should not be considered. The Wisconsin law covers this admirably in its use of the terms "actually used and useful for the convenience of the public."

Neither is it proper to figure on obsolete and expensive apparatus or material. Antiquated pumping engines which could only be actually duplicated by making new patterns; and masonry for which better and cheaper concrete would now be used, are examples.

CLOSURE BY MR. JOHN W. ALVORD

In closing this discussion the author feels unusually favored that so many able members of the Society have found time and interest enough to present ideas on this subject of going value, and more particularly that so many have recorded their frank variance with some of the ideas set forth. It is clearly through differences of opinion on the part of those who have studied a subject in a spirit of reasonableness that we draw near to the goal of truth toward which we strive.

It is somewhat to be regretted that a considerable proportion of the discussion is broader than the subject of the paper, not but that breadth of discussion is often valuable, but in this case it perhaps tends to lack of clearness. The paper it may be remarked deals only with one item of one of several methods of valuation, viz: the item of going value in the method of reproducing at present cost. Some of the discussion refers to other methods of valuation, and is somewhat confusing because this is not clearly stated.

There are at least three, and perhaps four, well approved methods of valuing a public utility property of the kind in question, all of which are proper under certain circumstances:

1. The method of reproducing its property and business at present cost, lessened by any depreciation the original plant or business has suffered.

2. The method of ascertaining the actual past investment from books of account, in which case neither depreciation or appreciation is usually considered.

3. The method of determining value by the market price of

stocks and bonds, when an active and representative market can be fairly said to exist.

4. The method of valuing from the standpoint of a willing seller to a willing buyer who, as a judicious investor, judges the plant by a careful analysis of its income, privileges, duties, and the future prospects of the city it serves, without going greatly into cumbersome detail.

The paper deals only with the first named method of valuation, and only one item of that method, viz: the reproduction of its business. We should not confuse this method with the determination of going value under any of the other methods, because going value may be found in quite a different manner under other methods of valuation; thus, for instance, the past cost of going value, discussed in the Marinette case by the Wisconsin Public Utility Commission, should be differentiated from the present cost of reproducing going value, just as the past cost of a pump or a set of pipes may be quite different from the cost of their present cost production. It seems to me clear that the past cost of going value can only be properly used in connection with the past cost of the whole plant under consideration as in the second method mentioned. To mix past cost data with the method of reproducing at present prices seems to me to mix two things which are unlike, and which therefore, is a procedure which is illogical and improper. Past cost will, of course, always throw light on present value, but if the estimator is determining the present cost of reproduction, he must logically stick to present reproduction to the end. To abandon his method at some certain stage because it does not suit him, and go to some other method of valuation, is a confession that he either does not understand the proper application of that method, or is not honestly willing to abide by it because the results do not suit him.

Mr. Williams' suggestion that this discussion is properly limited to a public utility is a wise one. This was not made clear at the outset of the paper. Some of the confusion of ideas in the discussion is undoubtedly due to the fact that we are not here discussing the valuing of a competitive business but a virtual monopoly hedged by contractual rights and obligations on both sides.

The writer is unable to follow Mr. Williams' distinction that the value of a created income is different from the cost of reproducing a given income. It is possible he might draw this distinction properly under some other circumstances but here we are discussing the values found by discovering the *cost of reproduction* and for the moment are necessarily assuming that the value of a created income will be the cost of its reproduction just as we assume under this method that the value of a pump will be the cost to reproduce it. It may be, after completing our work of reproducing, we shall find that the value of the plant is not found accurately by estimating the cost to reproduce [Mr. Williams himself points this out at the close of his discussion], but is better and more properly found by some other method, say past cost, or investors' analysis, but that cannot affect us in computing going value under the method of reproduction. We are compelled there by the very method we have adopted of assuming for the moment that the value of the created income is the cost of reproducing it, and the paper does not attempt to discuss any other view, although other views have their proper time and place under some other heading, nor do I see the force of his illustration that it is impracticable to consider that a $10,000 annual income might cost $20,000 to start "going." Such a statement does not turn $10,000 of value into $20,000 of value. It seems clear to me that if it cost $20,000 to rehabilitate an annual income of $10,000 that the value of that income in connection with the physical plant is $20,000, when computed for a public utility *under the method of cost to reproduce.* This difference of opinion therefore seems to me to be only due to extending the discussion beyond the scope of the paper, and considering the definition of going value as applying to values obtained by means other than those derived from the method of reproduction.

Mr. Williams is nevertheless an exceptionally clear thinker on this subject, and his analysis of the method of computing going value and the resulting debits and credits is worth careful study, and is a valuable contribution to the discussion.

Both Mr. Bryan and Mr. Kiersted seem to think that the hazards of the water works business should enter into the computation of going value. I can hardly bring myself to agree with this. It seems to me that that is a subject to be separately considered after the cost of reproduction has been ascertained, and the proper depreciations made, but the writer sympathizes much with Mr. Kiersted's desire for a simpler method of computing going value, and has passed through all the phases of mind that accompany a sincere search for a more explainable and easy basis of computation without satisfactory result.

Mr. Maury has added an exceedingly interesting and instructive analysis as to the probable acquisition of business of a hypothetical starting plant, which, considering his valuable practical experience, is worthy of thought. He also raises that interesting and still unsettled question: "Shall going value be computed upon actual rates or upon rates under a fair return?" So far going values have been predicated upon actual rates quite largely.

Most of the opinion expressed seems to be adverse to the theory that the city's option has a value which is best measured by what may be called "the unearned increment portion of going value;" that is, the losses incurred during a construction period. Most of the argument against the suggestion seems to lose sight of the fact that in holding such an option the city has retained the right to step at once into all the privileges of *the particular plant* in question at a given time without awaiting a construction delay. I do not see anywhere an adequate discussion of this point, and I cannot help but feel that without more thought and further study, the opinions expressed are not quite as deliberate and thoughtful as I would desire. I am content, therefore, to commend to notice the illustration used by Mr. McDonough of Fort Smith in the discussion and my reply, and then leave this question for the future, feeling that it may yet be better understood.

In conclusion, it may be said that the discussion has been unusually instructive and interesting. It is, of course, impossible in a closure to touch upon the many points raised which might be mentioned as of interest. It is, however, hoped that enough has been placed on record to clear away some of the misconceptions that have arisen over this subject and afford a basis for progress toward a uniformity of ideas, at least among those engaged in the work of valuation.

THE DEVELOPMENT OF THE WATER SUPPLY AT SUPERIOR, WISCONSIN, WITH SPECIAL REFERENCE TO THE IRON REMOVAL PLANT NOW IN OPERATION.

WM. C. LOUNSBURY.

The purpose of the writer is to present an account of the water supply of Superior, Wisconsin, not in a technical paper, nor altogether a popular one, but one which I hope may be of some interest.

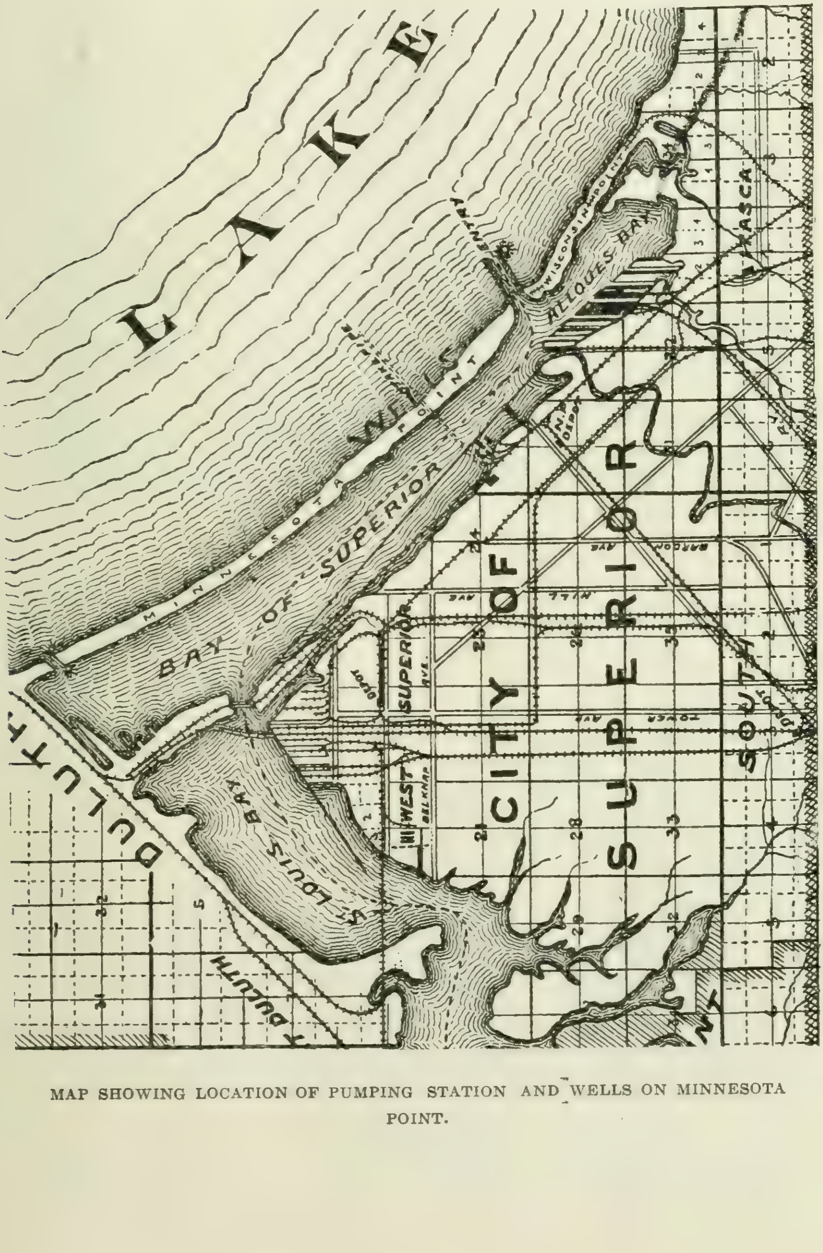
Superior is a rapidly growing city on a magnificent harbor at the head of Lake Superior. It is three-hundred and fifty miles northwest of Milwaukee and next to our convention city is the largest in the state. The site of the present city was largely cut-over timber in the early eighties. In 1890 the population was not quite 12,000 people; at the present time it is over 40,000.

The water supply is controlled by a private corporation, the Superior Water, Light and Power Company. During the early days, the supply was drawn from Tower Bay Slip, at a point in the harbor very near the town, but soon this plant was abandoned and a new station built two miles southeast; the water again being taken from the Bay.

The extension of the docks and the gross pollution of the harbor compelled the abandonment of this intake and plant also, although attempts were made to purify the water by the use of a coagulant and mechanical filters.

In 1889, the present corporation took over the old water company and in 1891 built a new plant at the place indicated on the view. In 1900 the building was enlarged and new machinery installed, making the present home of the Water Works.

When this location was adopted, a twenty-four inch intake was laid from the Pumping Station across the Bay and Point and into Lake Superior, the total length of submerged pipe being six thousand seven hundred and fifty feet, four thousand three hundred and fifty feet being under the polluted water of the Bay and one thousand eight hundred feet extending into the



MAP SHOWING LOCATION OF PUMPING STATION AND WELLS ON MINNESOTA POINT.

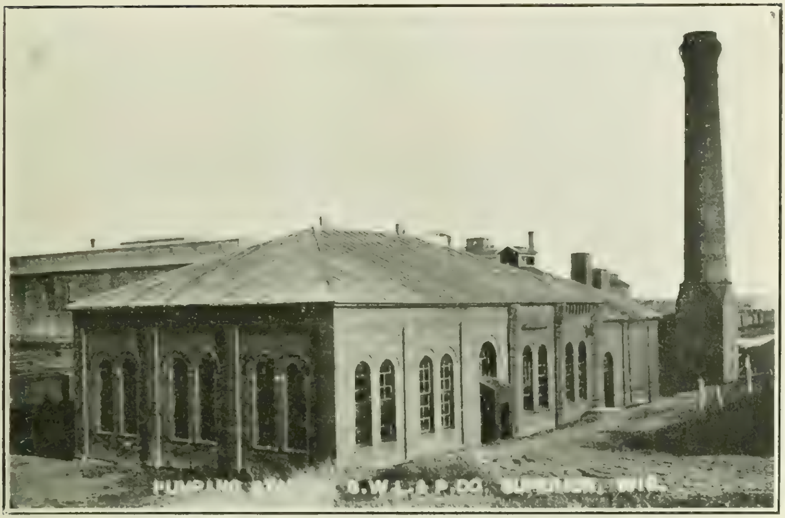
Lake. The difference, six hundred feet, represents the width of the Point at this place.

Water was drawn directly from Lake Superior from 1892 to 1897, when, on account of the pollution and turbidity of the Lake, due in part to the dumping of harbor dredgings, and in part to the danger of pollution from sewage flowing through the two harbor entries—one, 1¼ miles south, the other four miles north—the Lake supply was given up, and an extensive well system constructed on Minnesota Point. Minnesota Point is composed of sand varying greatly in composition, from gravel to fine clay, but about 50 per cent of it is such as is retained by a forty mesh sieve. Incorporated in the Point is considerable débris, and over large portions of it is a luxuriant growth of pines.

It was thought that with wells driven into this beautiful sandy beach, with Lake Superior pressing against them on one side, and the Bay of Superior six hundred feet away on the other shore, an inexhaustible supply of the purest of water would be obtained. Accordingly, eighty wells were jetted to depths of about forty feet; these were all connected to a header, each well being separated from this header by a nipple and gate. They were all six inch except four which were eight inch, and carried twelve or fourteen foot lengths of Cook strainers. The wells were spaced about sixteen feet apart, and as put down were from forty to sixty feet from the water. Changes in the beach have brought the water almost over the ones originally most distant, and have built up a goodly width of beach in front of those originally nearest the water. High water, however, washes over the system.

These wells were connected to the same intake which formerly was used to carry the water across the Bay, and the entrance of Lake water shut off by a twenty-four inch gate. This gate might still be used in an emergency.

The well water must have been a bitter disappointment, for it contained about 1.7 parts iron, which supported a luxuriant growth of crenothrix. This organism spread throughout the city mains and settled in considerable quantities. As our system is a direct pressure one, in which the domestic pressure of seventy pounds is immediately raised to one hundred and twenty pounds upon the receipt of a fire alarm, it is easy to



MINNESOTA POINT

imagine what occasionally was drawn from the water faucets when fire pressure stirred the sediment throughout the city, and carried it into the house services. Also, the well water turned yellow soon after drawing it from the wells, and appeared more or less like the Bay water. As the water was drawn by suction under the Bay, and it was generally believed the intake pipe leaked, the yellow color of the city water and the brown settlings of crenothrix in it were erroneously interpreted by the public to mean heavy Bay pollution; consequently, the city water acquired a reputation which was very unsavory and which only recently has been lived down.

POSITION OF WELLS—NOTE TOP OF WELL IN LOWER LEFT CORNER

The upshot of considerable agitation in the city was that the ompany decided to put in an iron removal plant, to precipitate the iron and so get rid of the obnoxious growths and color. Accordingly, an extensive investigation was undertaken and a report made by three experts to Hon. Wm. R. Merriam, the president of the company (in 1899). Both slow sand and mechanical filters were experimented with and considerable data accumulated.

After this report was made the company employed Mr. Allen Hazen, of New York, to design and build an iron removal plant, and the present plant was built in 1899. It has been fully described in *Engineering News*, Feb. 21, 1901. The plant was similar in design to those in use in Far Rockaway, Long Island, and other places. In these plants thorough aëration, and the removal of the carbonic acid were the essential features. Such treatment chemically changed the iron from a soluble to an insoluble state, or in other words, oxidized the iron. The Superior plant essentially consists of an aërating device, three covered concrete filters, each sixty-seven by one hundred and seven feet, together with a regulating chamber and clear water reservoir holding 350,000 gallons. After the plant was in operation, samples of the water showed only a small iron reduction. Analyses were made by Mr. G. C. Whipple of New York, as follows:

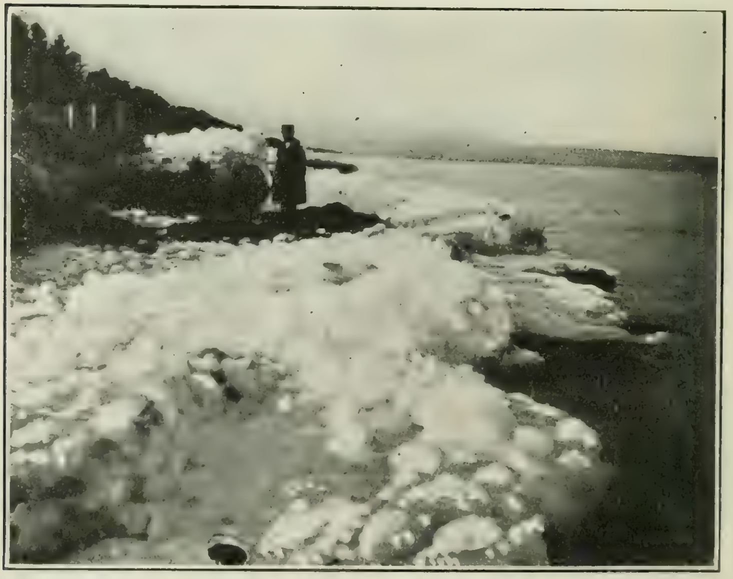
	PARTS PER MILLION OF Fe.	
	Before Iron Removal	After Iron Removal
1900	1.20	0.90
1903	1.50	1.10

Also, in 1900, Prof. E. G. Smith, of Beloit, reported an iron reduction of from 1.50 to 0.90 parts per million.

The treatment, though not removing much iron, was a marked success in eliminating all traces of crenothrix growth from the water of the city, and the filtered water, upon standing, did not deposit any iron. The city water has contained practically no sediment and has given no characteristic iron trouble since the filters have been in operation, although the iron content has remained high, with a varying color from twenty-five to thirty-five.

The writer was employed by the company in 1906, at a time of considerable agitation over a recent typhoid outbreak. At that time, it would have been of considerable importance if

BEACH IN FRONT OF WELLS



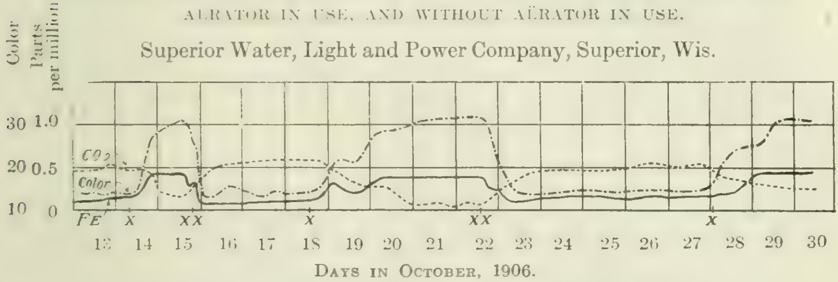
BEACH IN FRONT OF WELLS.

colorless water could have been delivered to the city, as we all know people are ready to believe well of a water if it only looks right. The use of potassium permanganate had been tried and, I believe, removed the color and the iron, but it clogged the filters and was impracticable, as well as costly.

To overcome this color in the filtered water has been one of our problems. During the summer of 1906, I came to believe that aëration was the greatest factor in the quality of the effluent. Previously the aërator had been enlarged to aërate more thoroughly; in October, we omitted its use entirely and ran the water direct from the pump into the filters. Hourly samples were taken before and after the change was made. The diagram will show the results obtained.

DIAGRAM SHOWING COLOR, CO_2 AND *FE* IN EFFLUENT FROM FILTERS WITH AËRATOR IN USE, AND WITHOUT AËRATOR IN USE.

Superior Water, Light and Power Company, Superior, Wis.



The time of putting the aërator into operation is marked with a cross, *X*, and the time of by-passing is marked with a double cross, *XX*.

For instance, on October 15, at about 5 o'clock in the afternoon, the aërator was by-passed.

		Raw	Filtered
4 p. m.	Color	20.	29.
	Carbon Dioxide	10.0	4.0
	Iron	1.30	0.75
11 p. m.	Color	37.	16
	Carbon Dioxide	9.0	6.0
	Iron	1.30	0.40
4 a. m. Oct. 16	Color	35.	13
	Carbon Dioxide	9.0	8.00
	Iron	1.25	0.20

SEVEN HUNDRED FEET FROM SHORE, MARCH 20, 1908.

ANOTHER VIEW OF THE BEACH MARCH, 1908.

These results have been repeated many times for more than two years, the last time in May, 1909. Simply omitting aëration, turns a colored effluent carrying from 0.80 to 1.00 part iron as the case may be, into a practically colorless effluent carrying a neglible quantity of iron.

These experiments have covered ranges of air temperature from − 30° F. to 90° F. and water temperatures from 34° F. to 60° F. Rates of filtration have varied with the varying hourly consumption of the city. Iron-free Lake water of a lower alkalinity has been mixed with the well supply, but our results have always been consistent.

When not using the aërator, the quantity of precipitate is so great and it is of such a sticky nature, we cannot operate in this way. When not using it, we have to clean filters more than twice as often, or every three or four days, instead of every eight to ten days. Consequently, although we have learned how to keep the color from forming, and to remove the iron, we have not the filter capacity to do it.

These same results were readily attained in bottle experiments carried on at the time of the first aërator experiments I made.

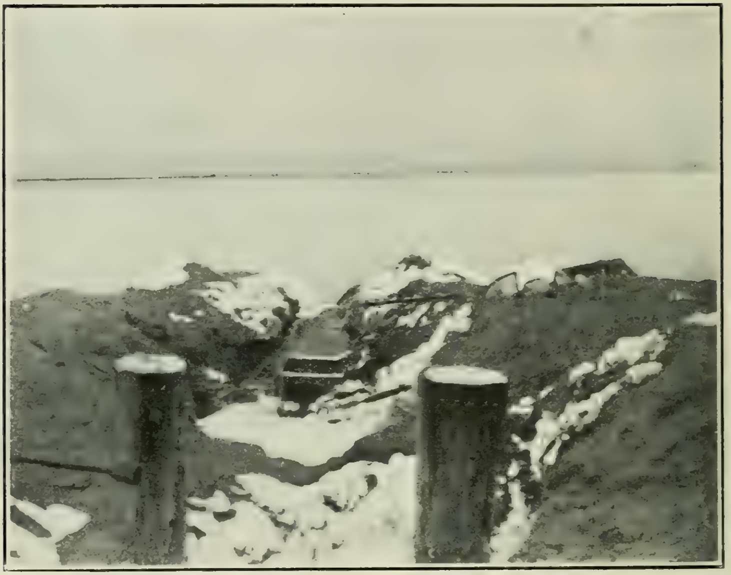
Raw water was drawn and placed in two bottles. Into one, carbon dioxide—freshly made from a generating bottle—was allowed to flow for some minutes. The other was left as drawn.

Both bottles had air to saturation in them. They were allowed to stand in the laboratory and the following observation made.

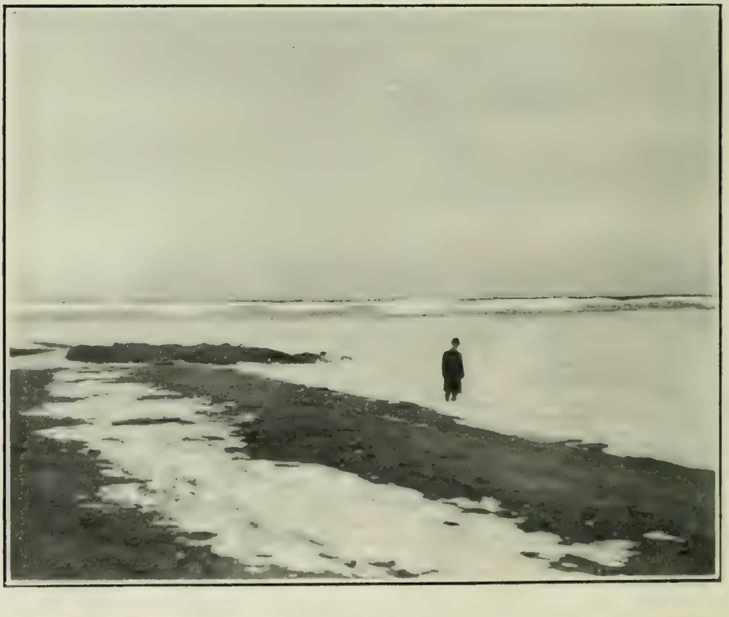
		As drawn	With CO_2
	Color	15	15
	CO_2	9.0	130
	Iron	1.7	1.7
3d day	Color	45	20
	CO_2	9	
	Soluble Iron	1.7	1.0
8th day—filtered through S and S paper	Color	45	23
	Iron	1.4	0.8

The bottle containing the more carbon dioxide precipitated its iron more readily.

Dissolved oxygen determinations have shown that the raw water as it flows from the pump before aëration, is about three-



SHOWING TRENCH TO LEAD WATER NEARER THE WELLS.



ICE DRIVEN ONTO BEACH IN FRONT OF WELLS BY STORM, MAY 2, 1909.

fourths saturated. As an explanation of the observed phenomenon, I stated, in 1906:

> It is clear the color is due to some obscure combination which is formed rapidly in the presence of oxygen, if carbon dioxide is absent or only small amounts present. It is partly or wholly kept from forming if carbon dioxide is present in considerable quantities.[1]

To revert to the well system again, I want to say a few words about winter conditions and how we have attempted to overcome the ice difficulties we encounter.

As the waves wash up on the beach during the early winter, the water sinks into the sand and freezes. The Lake, itself, does not freeze until late in January, or early February, so that, during the first half of the winter, the wash of the Lake on the beach and the spray from the surf freezes and builds a bank of ice along the shore, in front of the wells. When the Lake does freeze, the ice forms to a depth of about twenty inches; thus the water becomes solid in the Lake where the depth of water is less than this. As the beach near the wells has not much slope, the ice so forming may be solid on the bottom for a distance of forty to fifty feet, where in summer there is free water over the sand. Such conditions, of course, hold back the water so that at times it becomes difficult to get an adequate supply. To make matters much worse, we not only have to contend with the frost on the beach and the natural bank of ice described, but icebergs of considerable magnitude may line the beach, forming another dam outside of the barrier of shore ice.

In addition to the increased distance of the free water from the wells, in winter, it must be remembered that sand friction is greatly increased at low temperatures. According to Mr. Hazen[2] the lowering of the temperature from our maximum, 60° F. to our minimum, 40° F., would so increase sand friction that other things being equal, in winter we could only expect about 66 per cent of the summer flow. Hence it is of considerable importance to us to keep down the distance water must filter through the sand during the cold weather. The head in the sand is lowered, under these conditions, so that air is drawn into the system, which, in turn, causes us further trouble. As the water level is lowered, our suction must be increased, and as our suction is increased, our air troubles grow worse so we have no particular love for these winter conditions. To overcome this condition, in part, we dig trenches through the frost and ice to free water, thus allowing the water to flow through these trenches into the sand near our wells. These trenches must, of course be kept free of ice and must extend below the frost line. This April, while trenching, we found the frost in the sand extended three feet below the water level at a place which is now, in June, fifteen or twenty feet into the open Lake.

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[1] For full discussion, see paper by Mr. Robert Spurr Weston, Transactions of American Society of Civil Engineers, vol. lxiv, p. 112.

[2] "The Filtration of Public Water Supplies," by Allen Hazen, page 23.

DIGGING TRENCH IN WHICH TO LAY LATERAL PIPE FOR NEW WELL

To relieve this high suction on the wells in winter and to get a more abundant flow, is another difficulty we have been working on.

The writer has designed, this winter, a type of well which, he believes, will eventually give us a colorless supply, increase without ice or air difficulty our winter supply, and give us a satisfactory method of expanding our production with an iron free water.

What the writer proposes is simply this. Construct additional wells not on the beach but out on the Lake, itself. Last December, we placed such a six-inch well seventy feet out from the system and connected it to the suction main through one of the old wells. This new well gave us a water entirely different from that of our other wells. We got a good flow of clear, crystalline water, bacteriologically pure, with a color of six, alkalinity of thirty-seven and *no iron*. Our experience with this well and the fact that we found the sand of the beach, under the Lake, very compact, has led to the design of the well I now call to your attention.

This well differs from the experimental one in use, in having a double horizontal, instead of a vertical point, thus making a uniform sand cover and presenting a greater surface of strainer to the percolating water. The area of the strainer openings is very large to reduce suction. The points will be under free water at all times of the year. The ice bank cannot bother it, as the Lake bottom does not freeze so far into the Lake, and free air cannot get into it, as all the system will be water sealed, and a sand cover of seventeen feet will insure purity.

Thus, it seems to us, that at one stroke such wells will relieve us of the air problem, of the iron removal troubles, and present a method of extension which is inexpensive and elastic and which will give us our much desired crystalline, color-free water. I would particularly like to hear criticisms of this proposed well.

Although we have had our engineering troubles, I do not wish to close without some reference to the sanitary quality of the Superior water supply. Since 1906, we have daily records of analyses and seldom have the total number of bacteria on gelatine with four days count been above five, and day after day our plates are sterile with no growth whatever, in 1 cc. of dextrose broth. Few cities in America we believe have so pure a supply as Superior.

APPENDIX.

For the sake of completeness, the writer wishes to give additional data, as follows:

Table showing summarized results of aërator experiments. When operating without aëration, the raw water was run directly onto the filters, from the pumps; when operating with aëration, the water was pumped to the top of the aërator, from whence it fell about twenty feet, as spray, through four succeeding perforated iron trays.

	Average Color	Average Iron
Oct. 31 to Nov. 7, 1906, without aëration	14, constant	0.35 constant
Nov. 7 to Nov. 21, with aëration	32, 28 to 35	0.80
Nov. 21 to Dec. 17. without aëration,	14 constant	0.30, 0.20 to 0.30
Dec. 17 to Jan. 1, 1907, with aëration	31, 28 to 34	0.80, 0.60 to 1.10
Jan. 1 to Jan. 13, without aëration	14, 13 to 15	0.30, 0.25 to 0.40
March 8 to April 17, with aëration	30, 28 to 35	0.80 to 1.20
April 19 to April 22, without aëration	14	0.40, 0.3 to 4

ANALYSIS OF AN AVERAGE SAMPLE OF THE SUPERIOR WATER.

	Parts per Million	
	Raw Before Aëration	Filtered After Aëration
Color	20	32
Turbidity	3	1
Total albuminoid ammonia	.030	.018
Free ammonia	.010	none
Nitrates	none	none
Nitrites	none	none
Total solids	80	78
Chlorine	1.0	1.0
Total hardness	46	46
Alkalinity	49	49
Incrustants	none	none
Iron	1.6	1.0
Manganese	0.12	......

	Parts per Million	
	Raw Before Aëration	Filtered After Aëration
Free carbon dioxide	12.0	4.0
Dissolved oxygen (Per cent saturation)	96.9	
Bacteria per cc. on gelatine, 4 days	2	0
1 cc. in dextrose broth, 24 hours at 39° C.	No growth	No growth
10 cc. in dextrose broth, 24 hours at 39° C.	Slight acid growth, no gas	Slight acid growth, no gas

IRON CONTENT OF WATER.

The iron content of the well water is not constant, but varies from 1.2 to 2.0 parts, and in general is higher in winter than in summer. The average of fourteen determinations, in October, 1906, gave an iron content of 1.4 parts, and twelve analyses, in March, 1907, gave 1.9 parts, the figures from the effluent being in the same periods, 0.75 and 0.90 parts respectively. These differences, I believe, are due to the varying amount of seepage of the Bay water, six hundred feet away on the other shore of the Point. In winter and spring, the free Lake water is farther away—as already noted—than in summer, and the Bay water is proportionately nearer.

ALKALINITY AND HARDNESS.

The Lake water has a hardness of only forty-two and an alkalinity of thirty-eight. The Bay water has a hardness of sixty-three and an alkalinity of sixty-five. These figures vary somewhat with the wind currents. It is evident, however, that the proposed wells, drawing more directly from the Lake, will give a softer water than the present supply.

DISCUSSION

Prof. J. M. Caird: I would like to ask Mr. Lounsbury if he has ever tried the use of lime to reduce the iron; and what action the lime has on the iron?

Mr. W. C. Lounsbury: At the time when I was working on the air experiment, I was also working on lime. We found that the lime will remove the iron.

Prof. J. M. Caird: Would it remove it as much as air?

Mr. W. C. Lounsbury: I have never tried it with the general supply; I have only tried it experimentally. The Lake water contains no iron or only a trace of it. The sand of Minnesota

Point itself contains large quantities of iron, so much that you can put a magnetic knife in the sand and dip it down, and bring it up glistening with particles of iron. There is however iron in the bay water on the other side, six hundred feet away.

Last night I wanted to rise and ask some of those Boonton experts if their process could not be applied for iron removal. I would like to ask them now if they are present.

Mr. Nicholas S. Hill, Jr.: I do not pretend to be a chemist, but I should hardly think that the application of chloride of lime in the quantities used in the Boonton plant would be efficient in removing iron. I doubt very much whether it could be applied in quantities sufficient to effect such a removal without deleterious effects; but the question has never suggested itself to my mind at all, and whatever I say would be tentative and offhand. I suppose it is a question that could be very readily answered if we had Professor Cornwall here, or some expert on the chemistry of the subject.

H. F. Dunham (by letter): It is a pleasure to be able to acknowledge and correct an error made by the writer in the discussion of a paper presented to the Amercan Society of Civil Engineers by Robert Spurr Weston upon The Purification of Ground Waters Containing Iron and Manganese.

The error related to the distance of the wells from the lake at Superior, and it may be reasonable in view of later improvements there, to copy the writer's brief discussion of Mr. Weston's paper read to the Society February 3, 1909:

> At Superior the wells are four hundred feet from the shore of the lake. The lake water, like most surface-waters, contains little iron, yet it is undoubtedly the source of the water supply. What would be the change in the quantity of iron in that supply if the wells were forty feet, instead of four hundred feet, from the shore line? It seems hardly reasonable to think there would be greater difficulty in maintaining wells at that or even at a less distance from the shore. If the iron is taken up as the water percolates through the sand, a less distance might yield less iron.
>
> A marked improvement in the number of parts of iron per million followed the location of a system of wells close to and partially underneath an Illinois stream. In water from sand bars in a Southern river the iron diminished to one-fourth of the first determined amount under continued pumping from a group of wells during a season when the iron in the river water was steadily increasing. However, it was at all times less than the amount of iron in the sand-bar supply, but the distance of

wells from surface waters and the diminution in quanity of iron under the long-continued operation of a plant are items of interest.

Without personal knowledge of the conditions at Superior the writer believes the original wells are too near each other as well as too far from the Lake.

COALS FOR HAND FIRED STEAM PLANTS

D. T. RANDALL

Steam is being generated in all parts of the country with the coals which are mined near by or which are available at a reasonable freight rate. Some are burning coals which others would consider as impossible fuel for their plants.

It is generally known that there is a difference in the character and heating value of the coals mined in the United States, and yet very few people realize how great these variations are.

Much coal is left in the mines of West Virginia and Pennsylvania as being of such low grade that it will not pay to market it. This so-called low-grade coal is, however, but little less valuable than the regular output of the mines and is in many cases much better than the best coal mined in the States farther west.

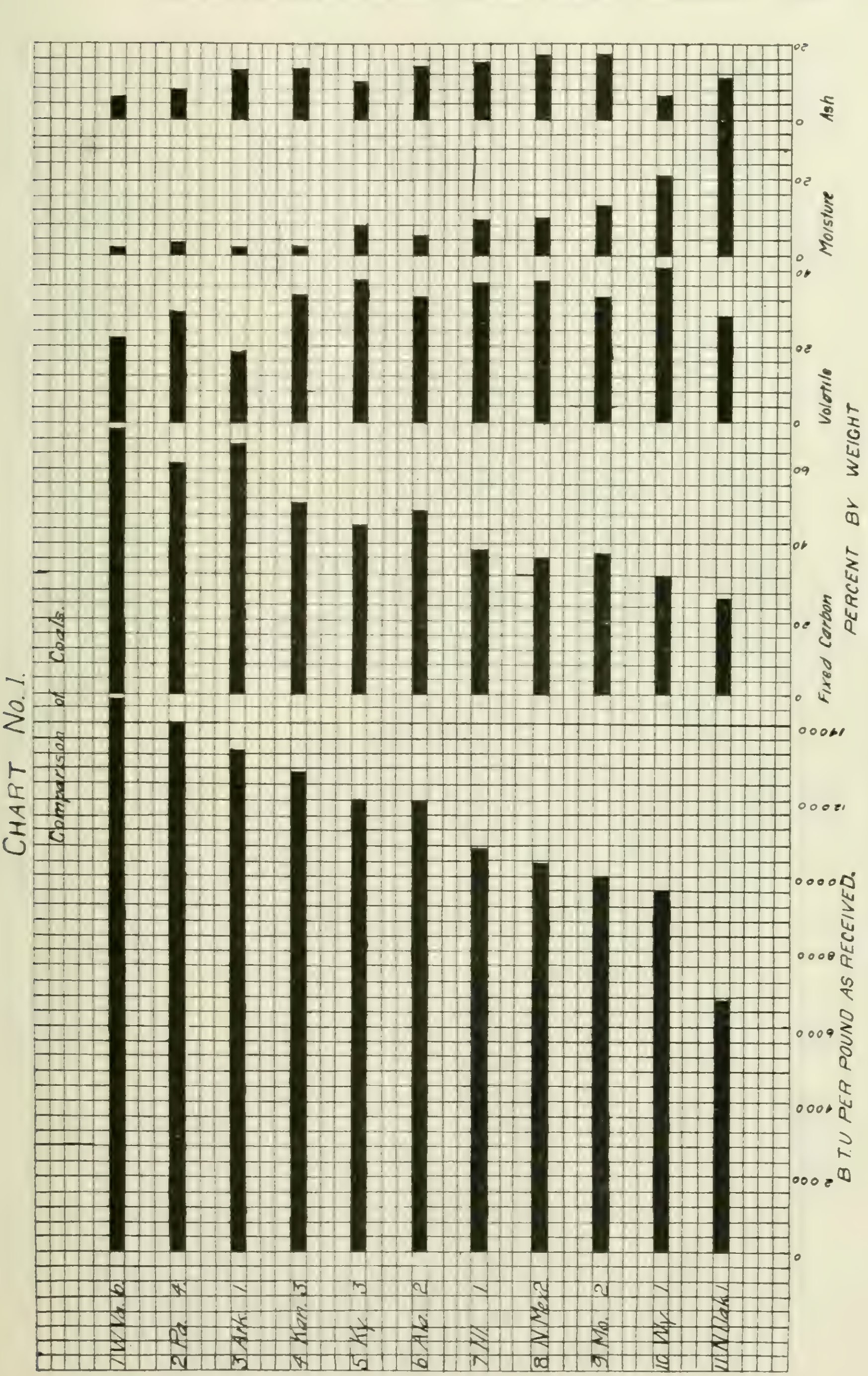
Preference is naturally given to those coals which have a small percentage of ash and do not clinker badly, and to the larger sizes such as lump or egg.

To show the differences in coal mined in the United States, Table No. 1 and Chart No. 1 have been prepared from results taken Professional Paper No. 48 of the United States Geological Survey.

TABLE 1

Coals Tested on a Hand-Fired Grate Under a 210 Horse-Power Heine Boiler (See U. S. G. S., pp. 48)

	ANALYSIS OF COALS AS FIRED.					COAL MOISTURE AND ASH FREE.		
	Fix. Carb.	Volatile	Moisture	Ash	B. T. U.	Fix. Carb.	Volatile	B. t u.
West Virginia . . 6	70.03	22.38	2.14	5.45	14639	75.78	24.22	15841
Pennsylvania . . 4	60.82	28.70	2.90	7.58	13982	67.94	32.06	15619
Arkansas 1	66.36	18.61	1.99	13.04	13302	78.10	21.90	15654
Kansas 3	50.99	33.52	2.03	13.46	12746	60.40	39.60	15082
Kentucky 3	44.84	37.32	7.92	9.92	12003	54.58	45.42	14609
Alabama 2	48.65	32.98	4.83	13.54	11948	59.60	40.40	14638
Illinois 1	38.21	36.91	9.69	15.19	10706	50.86	49.14	14252
New Mexico 2	36.11	37.30	9.92	16.67	10330	49.19	50.81	14070
Missouri 2	37.33	32.88	13.09	16.70	9995	53.17	46.83	14234
Wyoming 1	31.61	40.56	21.81	6.02	9630	43.80	56.20	13343
North Dakota . . 1	25.40	28.13	35.84	10.63	6674	47.45	52.55	12466



GRAPHIC COMPARISON OF COALS FROM DIFFERENT FIELDS

The technological branch of the United States Geological Survey has been conducting tests on all the fuels of the country and many valuable facts have been established regarding the character and the best methods of utilizing them.

Experience in burning coals from all sections of the country in a hand-fired furnace indicates that for such an equipment (see United States Geological Survey Bulletin) the size of the coal is not of as much importance as is usually thought to be the case, but the smaller sizes require more draft and are slightly less efficient.

Nor does the ash affect the results as much as might be expected. Small variations in the percentage of ash seem to have but little effect except in so far as the heating value of the coal is varied.

Owing to the fact that the moisture, ash and volatile matter usually increase together in the poorer coals, it is difficult to separate the effects of any one of them from the other. Table No. II seems to indicate, however, that the larger percentages of volatile matter make the coal more difficult to burn completely. The moisture and ash also have an influence on the results.

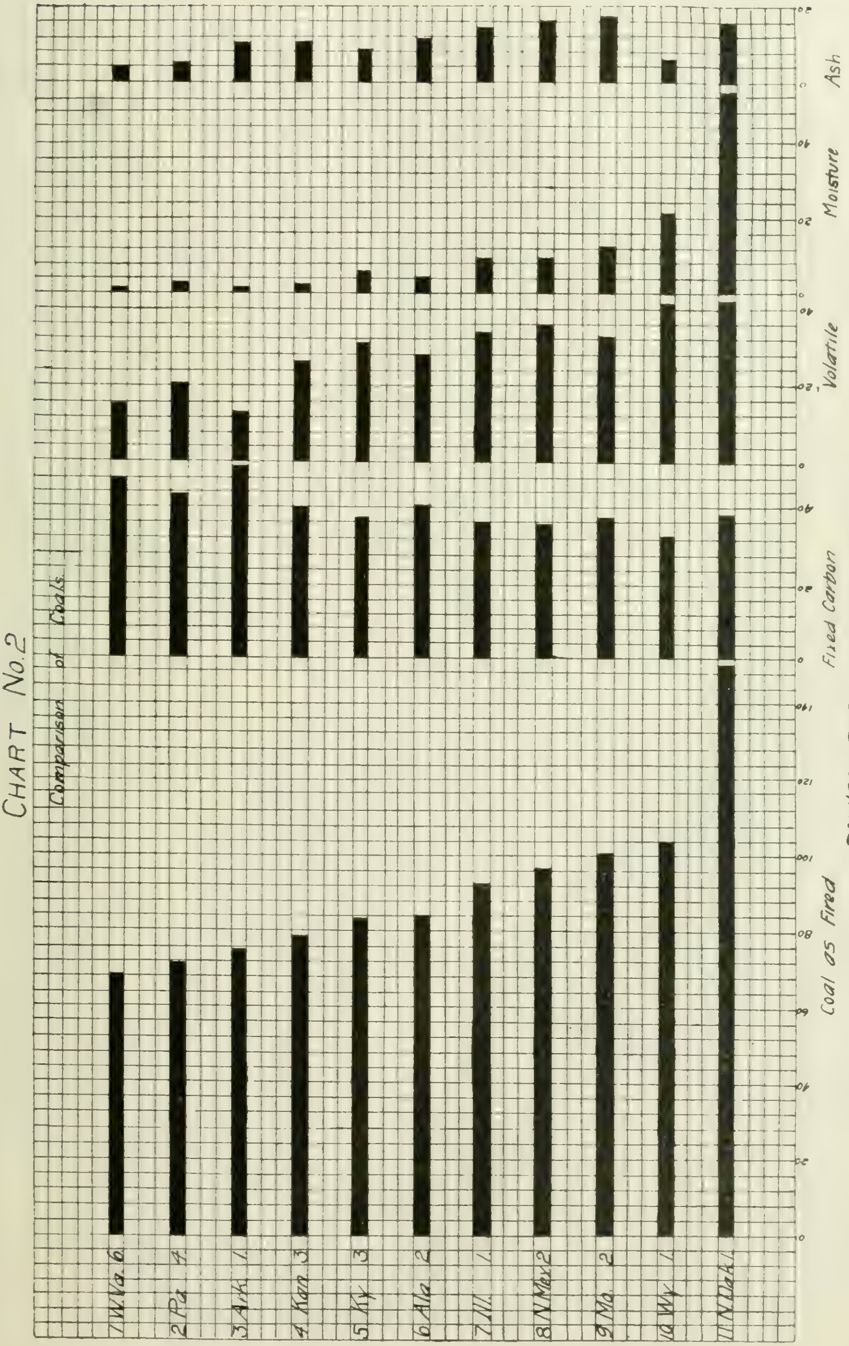
TABLE II

The Relation of Volatile Matter in Coal to Efficiency of House Boilers

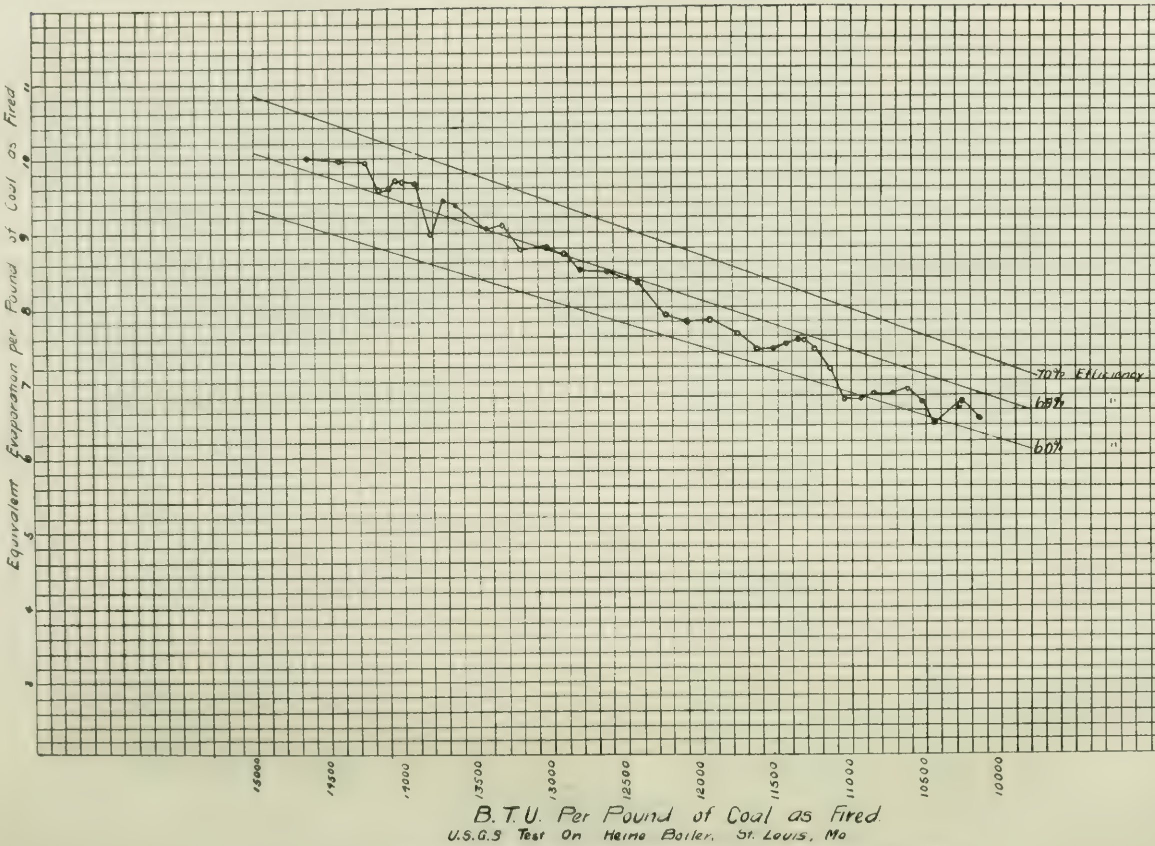
NO. OF TESTS AVERAGED	VOLATILE MATTER IN THE COMBUSTIBLE (PER CENT)	EFFICIENCY (PER CENT)	PER CENT RATED CAPACITY DEVELOPED	BLACK SMOKE (PER CENT)	ASH IN DRY COAL (PER CENT)	SULPHUR IN DRY COAL (PER CENT)	CLINKER (PER CENT)	PER CENT CO_2 IN DRY FLUE GASES	PER CENT CO IN DRY FLUE GASES
4	18.30	60.56	63.7	18.2	8.00	1.33	0	8.7	0.44
12	22.71	56.33	61.1	18.0	8.94	1.74	0	7.3	0.54
7	34.70	54.11	52.8	22.1	11.27	1.23	2.9	7.4	0.50
11	38.79	47.19	57.1	30.8	15.02	2.64	12.0	8.7	0.65
16	44.46	47.19	61.3	32.9	14.57	4.35	30.4	9.1	0.72

These tests on house boilers show that for wide ranges of volatile matter there is a considerable difference in the results. These are significant, as they were obtained on a type of furnace which is most unfavorable to perfect combustion, and therefore make the effect of the composition of the coal more marked.

For a range of volatile matter between 18 per cent and 40 per cent, the efficiency varies about 12 per cent in favor of the low



GRAPHIC COMPARISON OF COALS ON BASIS OF AMOUNTS REQUIRED TO SUPPLY 1,000,000 B. T. U.



RELATION BETWEEN SIZES OF COAL AND SEVERAL ITEMS volatile coals. (See Bulletin United States Geological Survey, 366.)

On tests with a Heine boiler, hand-fired, this variation is only about 6 per cent owing to the better methods of firing and to a better type of furnace. It is probable that a furnace may be designed to burn high volatile coals with practically the same efficiency as is obtained with the low volatile coals.

To show the relative amounts of coals and their constituents that must be fed into a furnace to furnish it with 1,000,000 B.t.u., Table No. III and Chart No. 2 have been prepared:

TABLE III

Comparison of Coals in Table I on Basis of Amounts Required to Supply One Million B.t.u. to Furnace

	POUNDS COAL PER 1,000,000 B.T.U.	POUNDS FIXED CARBON PER 1,000,000 B.T.U.	POUNDS VOLATILE MATTER PER 1,000,000 B.T.U.	POUNDS MOISTURE PER 1,000,000 B.T.U.	POUNDS ASH PER 1,000,000 B.T.U.
1. West Virginia ..6	68.31	47.84	15.29	1.46	3.72
2. Pennsylvania...4	71.52	43.50	20.53	2.07	5.42
3. Arkansas 1	75.17	49.88	13.99	1.49	9.80
4. Kansas 3	78.45	40.00	26.30	1.59	10.56
5. Kentucky......3	83.31	37.56	31.09	6.60	8.26
6. Alabama.......2	83.69	40.71	27.60	4.04	11.33
7. Illinois 1	93.41	35.69	34.47	9.05	14.19
8. New Mexico....2	96.80	34.95	36.10	9.60	16.14
9. Missouri 2	100.06	37.35	32.90	13.09	16.71
10. Wyoming.......1	103.84	32.82	42.11	22.65	6.25
11. North Dakota...	149.83	38.05	42.14	53.70	15.93

This is a more convenient basis of comparison than the analysis as usually given. However, this does not give an entirely correct comparison for the reason that not all of the heat as reported in the B.t.u. values is available to the boiler. The percentage of available heat varies with moisture and other constituents of the coals. These values if calculated would compare with the so-called low values used for gases and in some cases for liquid fuels. As there is at present no accepted standard for determining the corrections to the heating values of coals for boiler use the above table has been submitted without an attempt to correct values.

Chart No. 3 shows the relation between heating value of the coals and water evaporated in the boiler per pound of coal fired for about 400 tests:

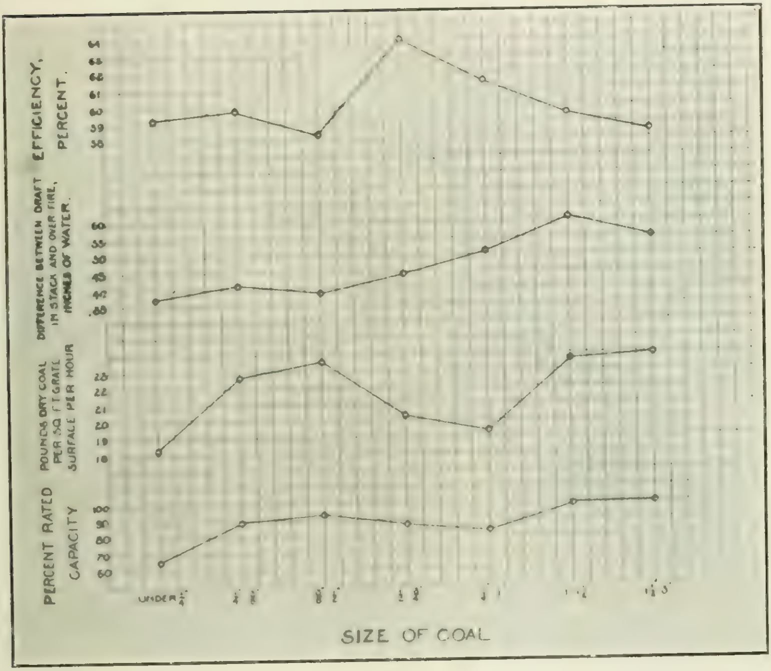
It will be noted that in general the evaporation has been nearly in proportion to the heating values of the coals. In some cases the coals of higher heating value did not give as high results as others of lower heating value. This may be due to either of two causes. The composition or size of the coal may be such as to make it difficult to burn it all completely, or the method of firing and the air supply may have been at fault. The results shown in the diagram are not corrected for influence of size of the coal, loss of carbon in ash-pit, loss of heat to evaporate moisture in coal, and loss due to the use of excessive amount of air in burning the coal. Many of the variations in results are due to one or more of the above causes.

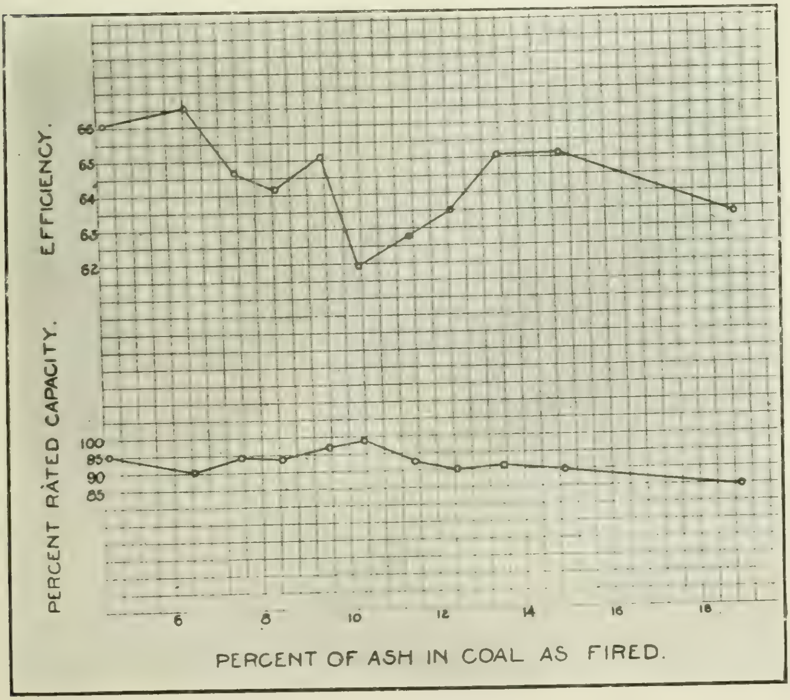
This shows that for an average the results depend principally on the heating value of the coal when the coal is burned in a properly constructed furnace. Of course, the moisture. the ash and the volatile matter influence the efficiency. And the ash in larger amounts, and especially if it tends to clinker, reduces the capacity at which an equipment may be operated.

It must be understood too that not all of the heating value of the coals as determined by the calorimeter can be made available to the boiler. The moisture in coal requires considerable heat to evaporate it in the furnace. This varies from about ½ per cent of the fuel value in good eastern coal to about 1¼ per cent for Illinois coal and to about 5 per cent to 8 per cent for the lignites.

The most simple furnace and the one least suited to burn bituminous coal is the hand-fired grate with a small cumbustion space bounded principally by iron surfaces. This furnace is found in house boilers and locomotive types. The best furnace for most coals is one which is so designed that the coal is fed regularly in small quantities; air is admitted to the gases which are slowly driven from the coal, and combustion takes place in a large combustion chamber which allows the gases to burn before they reach the cold surfaces of the boiler tubes.

Time is required for the gases and air to burn and any means that will cause them to mix quickly will reduce the size of combustion chamber required to secure economy and smokeless combustion. A perfect furnace would burn all coals with equal


PERCENT RATED CAPACITY
60 70 80 90 100
POUNDS DRY COAL PER SQ FT GRATE SURFACE PER HOUR
18 19 20 21 22 23
DIFFERENCE BETWEEN DRAFT IN STACK AND OVER FIRE, INCHES OF WATER.
.30 .35 .40 .45 .50 .55 .60
EFFICIENCY, PERCENT.
58 59 60 61 62 63 64
UNDER ¼
SIZE OF COAL


EFFICIENCY.
66
65
64
63
62
PERCENT RATED CAPACITY.
100
95
90
85
6
8
10
12
14
16
18
PERCENT OF ASH IN COAL AS FIRED.

efficiency. The ordinary hand-fired furnace found in most plants is far from being a perfect furnace.

One should choose a coal suited to a furnace and boiler equipment, or else change the furnace to meet the requirements for a cheaper coal.

A strong draft is an important condition to be secured in a boiler plant. A tall stack is a good investment. Stacks should seldom be less than 120 feet high. In many cases they should be higher. A fan may be used with a shorter stack with good results. In many cases coals have been pronounced as unsatisfactory because the draft was too low.

In considering coal for boiler plants, it is necessary to know the coals which are available and their relative values. Some otherwise good coals may be unsuited because of trouble from clinker. Not always, but generally, the cheapest coal to buy is the lower priced one, provided conditions in the plant will permit its use.

In order to compare the cost of coals offered to the government they have been calculated on the basis of the cost of 1,000,000 heat units delivered. This varies from seven to twenty cents in different parts of the country. If the purchaser desires assurance that the same coal which he selects shall be delivered throughout the contract period, he naturally desires to make use of specifications covering the essential characteristics of the coal. The United States government, many state and city governments, and numerous commercial firms are now using such specifications with success. The specifications cover such items as price, method and time of delivery, and also establish a standard for the heating value of the coal, and the ash content. In some cases the permissible amount of volatile matter is stated. In many cases a specification is necessary in the purchase of coal in order that the purchaser may get what he pays for and pay for what he gets.*

The experiments of the technologic branch show that for almost any character of coal, furnaces may be adapted or new ones designed which will burn them with reasonable efficiency and that almost no fuel need be rejected as worthless. Even coals of small sizes and high in ash may be so prepared that when properly sized they will give results that are but little below those for the larger sized and better coals.

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* See Bulletin No. 339, United States Geological Survey; also No. 378.

DISCUSSION

Mr. Samuel B. Flagg: I am very glad of this opportunity to be with you and discuss Mr. Randall's paper on fuels for hand-fired boiler plants, but regret that Mr. Randall was not able to be present also. It is very gratifying to note the amount of time which has been devoted, or is to be devoted, in this convention to the fuel end of water works operation, and particularly gratifying to those of us who are engaged in the fuel testing work of the United States Geological Survey. With the permission of the chair, I would like to add a few words regarding one or two points suggested by Mr. Randall's paper.

The adaptation of the coal to the furnace, or the furnace to the coal, has been mentioned in the paper just presented. For the tests conducted by the technologic branch of the Geological Survey a comparatively good furnace was constructed, and the fireman employed on all of the tests was an expert fireman; nevertheless, under these conditions certain things have been brought out which I wish to show from a few curves; first, that the per cent of smoke developed on these tests increased as the per cent of fixed carbon in the coal decreased. This relationship is shown graphically in the diagram before you (Fig. 1), which is reproduced from Bulletin 325 of the Geological Survey. In preparing this diagram the results of a number of tests were averaged to obtain each point, and the points were then connected by straight lines. You will note that a curve so drawn as to average these points would show a decided tendency towards increased amounts of smoke as the per cent of fixed carbon decreases, or as the per cent of volatile matter increases.

The second fact brought out is that as the per cent of smoke becomes greater the per cent of carbon monoxide, as shown in the flue gas analysis, increases. (See Fig. 2.) In this case we again note that an average curve shows a distinct tendency upward.

Our third conclusion relates to the unaccounted for loss, one of the items in the heat balance. This item includes not only the heat lost by radiation, but also the loss from incomplete combustion of hydrocarbons and hydrogen. We note in the diagram (Fig. 3) that as the percentage of smoke increases the unaccounted for loss runs up, and runs up quite rapidly as the higher percentages of smoke are reached. Any losses due to tarry products which might escape and not be shown by the ordinary analysis would also be included in this item.

As a fourth deduction we note that the efficiency decreases with the increase in smoke developed. I have not a diagram representing this, but it is indicated by the results of the tests.

As stated before, the tests which are represented by these diagrams were carried on under favorable conditions. This is particularly true in regard to the method of firing the fuel, the chargings being small in amount and frequently made. Under ordinary operating conditions in a hand-fired plant we find that the attendants are usually not willing to put forth the extra effort necessary, but will rather do the work in the way that will require the least of their time. Under these circumstances we may expect to find more smoke and less economy.

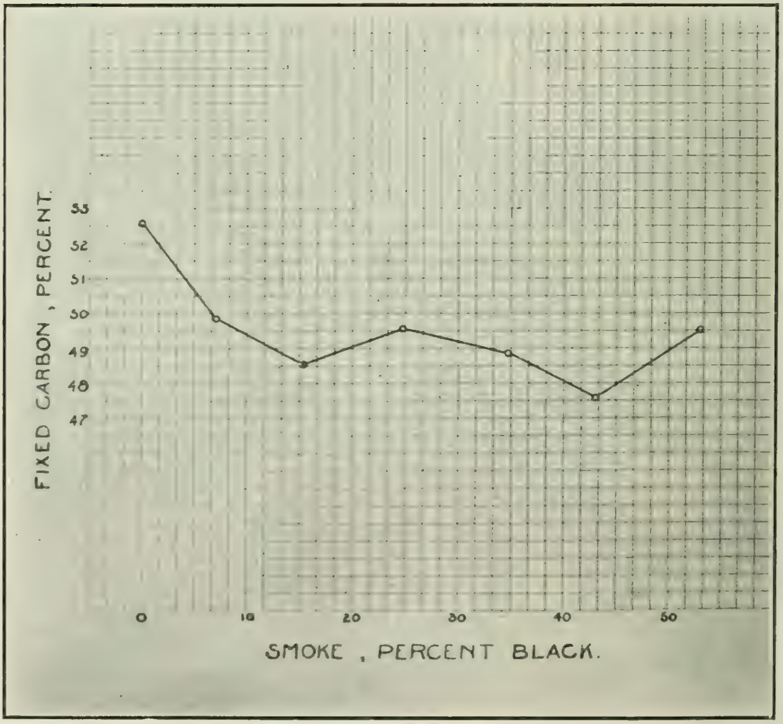


Fig. 1

In order to study the nature of the volatile matter driven off from coal under different conditions, a series of laboratory experiments were made under the direction of Prof. N. W. Lord of Ohio State University, by Dr. H. C. Porter and F. K. Ovitz in the chemical laboratories of the technologic branch of the Geological Survey. Some of the results of their work were given in a paper by Messrs. Porter and Ovitz read before the American Chemical Society, and published in the Journal of the Society. (Vol. 30, September, 1908.)

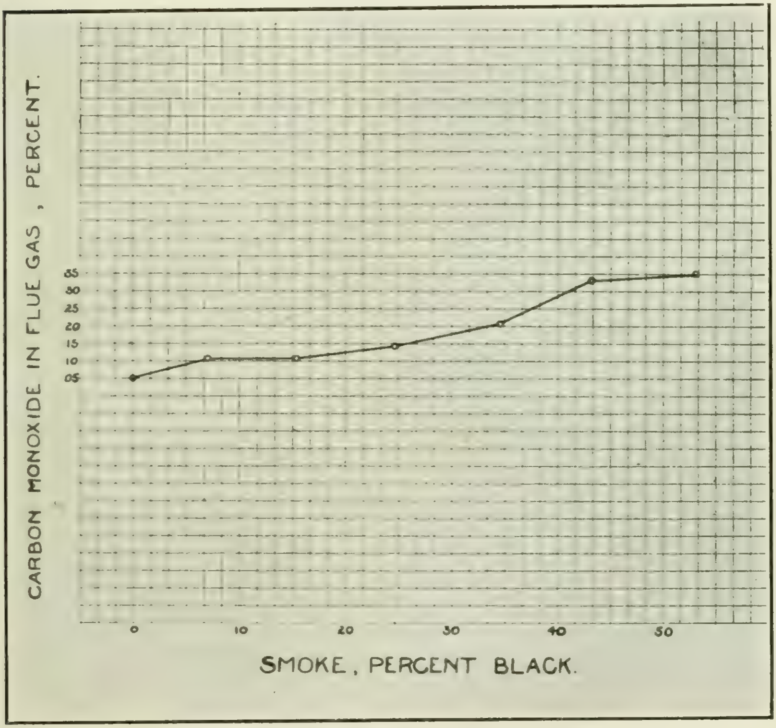


Fig. 2

These curves (see Fig. 4), taken from the paper mentioned, show the amount of smoke producing compounds given off from several coals when heated for a given length of time in a furnace at different temperatures. Four characteristic fuels are used, the Connellsville, Illinois, and Pocahontas coals belonging to the bituminous class, and that from Wyoming falling under the lignite classification.

In these experiments ten grammes of the coal, carefully weighed, was introduced into an electric furnace which had been brought to the temperature indicated in the diagram. The temperature of the coal itself was also noted by means of thermocouples and the amount and composition of the volatile matter given off in the first ten seconds determined. The results show that, of the four coals used, the Connellsville gives off the largest proportion of smoke-producing compounds. Further experiments are being made in order to extend these curves and also to obtain similar data for other coals, and results of this work will appear later in a bulletin of the Geological Survey.

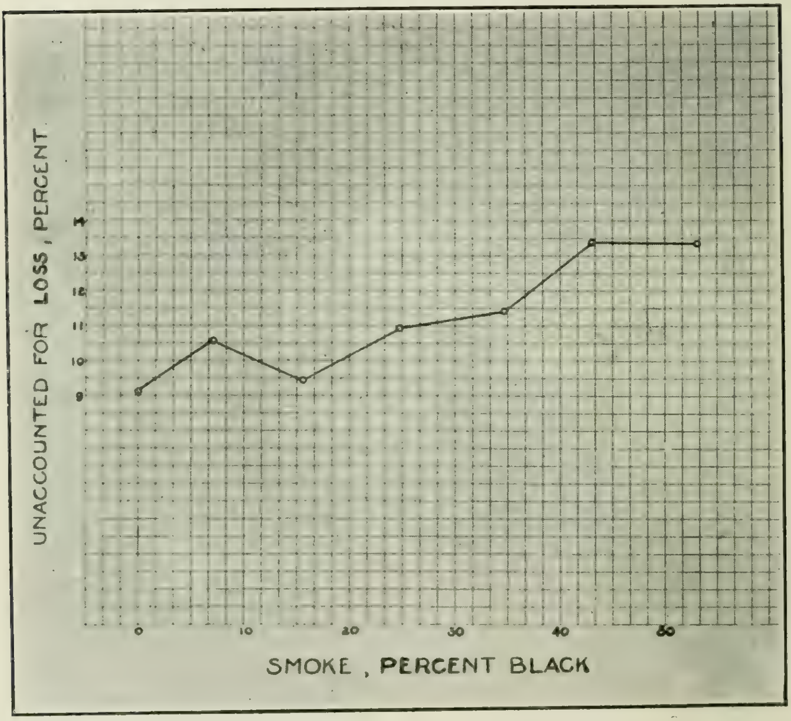


Fig. 3

We can see from the diagram just referred to that two coals when treated in the same way, may act quite differently. The importance of knowing the characteristic action of the various fuels of the country and the value of this information in designing a furnace suitable for any particular coal is becoming more generally recognized. It was with the idea of obtaining such data that the United States Geological Survey had built, at its fuel-testing plant in Pittsburg, Pa., a long combustion chamber equipped for making some special tests. The construction of same is quite clearly shown in the view. (Pl. B.)

At the right is a Murphy Automatic Smokeless Furnace, which is connected by a tunnel or long combustion chamber about thirty-five feet in length, to the combustion chamber proper of a Heine boiler. The setting of the boiler, with the exception of the connection to the long combustion chamber, is practically the same as shown in Professional Paper 48 and Bulletin 325. With this equipment it is possible to maintain a uniform rate of combustion and then, by taking observations at several points along the tunnel, to determine the length of gas travel necessary for complete combustion when running at various rates.

The results of these tests will be a help not only to the designer of furnaces to be fired by automatic stokers, but they should also furnish some data regarding hand-fired furnace details. The study of this problem is to be taken up by the Steam Section during the coming year to ascertain what constructive features and what method of firing different coals require for smokeless, as well as efficient combustion.

Mr. J. H. Brewster: I would like to ask Mr. Flagg if he has taken into consideration the volatile hydrocarbons in arranging the drafts on his boilers; that is, did you make any difference at all, or did you keep the draft the same during all your tests?

Mr. S. B. Flagg: The drafts were not the same for all coals nor for all tests on any one coal. In most cases several tests were run on a given coal and the most satisfactory draft conditions were not always obtained on the first test.

Mr. J. H. Brewster: Was the amount of volatile matter in the coal considered in the arrangements of the draft at all?

Mr. S. B. Flagg: It was in a general way, but there were other factors to be considered in determining the position of the damper. During most of the tests on coals containing a con-

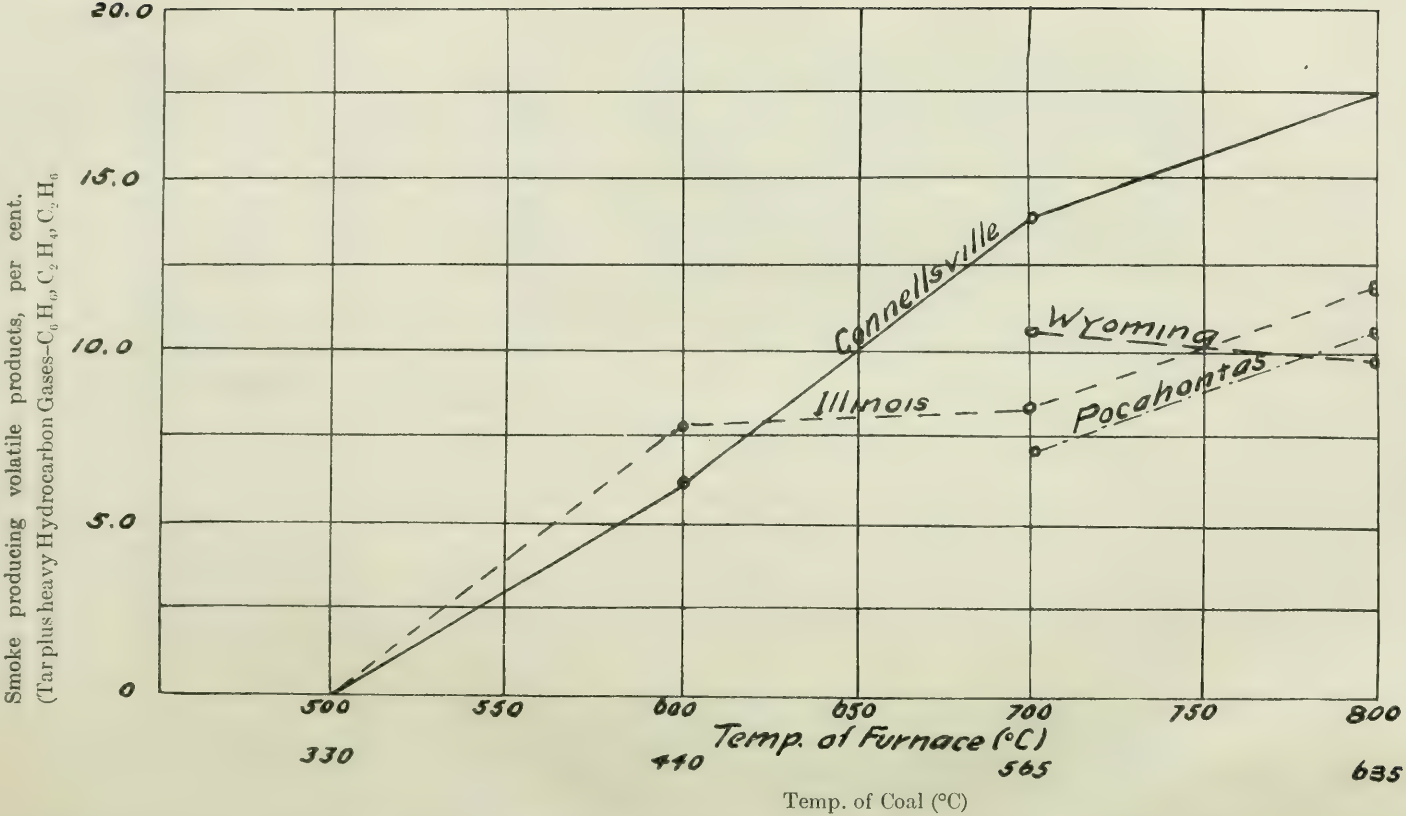


FIG. 4. PROPORTION OF SMOKE-PRODUCING COMPOUNDS GIVEN OFF AT DIFFERENT TEMPERATURES.

siderable proportion of volatile matter, extra air was admitted into the furnace over the fire immediately after firing. In some instances this was done by leaving the fire doors ajar for a few moments after charging the coal, and in others a smoke preventing device which was semi-automatic in its operation, was used.

MR. BREWSTER: In all highly volatile coals were the drafts allowed to stand open so that the gases could pass up the chimney?

MR. S. B. FLAGG: The position of the damper was determined by the amount of steam it was necessary to develop, but in most of the tests nearly all of the available draft was necessary, so the damper was almost wide open.

MR. J. H. BREWSTER: In all highly volatile coal was the draft allowed to stand open so that the gases could pass up the chimney?

MR. S. B. FLAGG: Yes.

MR. J. H. BREWSTER: Was it considered that the gases were of value in the efficiency of the coal in getting heat from it? You allowed your gas and the heat from it to pass up the chimney; and my point is simply this, that it strikes me a difference in those dampers should be made with the highly volatile coal as against one with high fixed carbons, because you would not get as much value out of the highly volatile coal, allowing the heat to pass up, as you would if your dampers were checked so as to retain your heat and use it.

MR. S. B. FLAGG: If I get Mr. Brewster's point, he means that when burning a high volatile coal, the dampers should be partly closed so as to retard the flow of the gases and give time for complete combustion of the hydrocarbons. As a matter of fact, it is not possible to accomplish the desired result in this way, for the reason that the position of the damper will be determined by the power that is required of the boiler.

The complete combustion of the volatile matter must be accomplished by maintaining the furnace at a sufficiently high temperature and admitting the right quantity of air, which latter must be thoroughly mixed with the combustible gases before they have reached the cooler parts of the setting. In other words, it is not a question merely of velocity of the gases but rather of proper air supply and mixture of same with the gases at the right temperature.

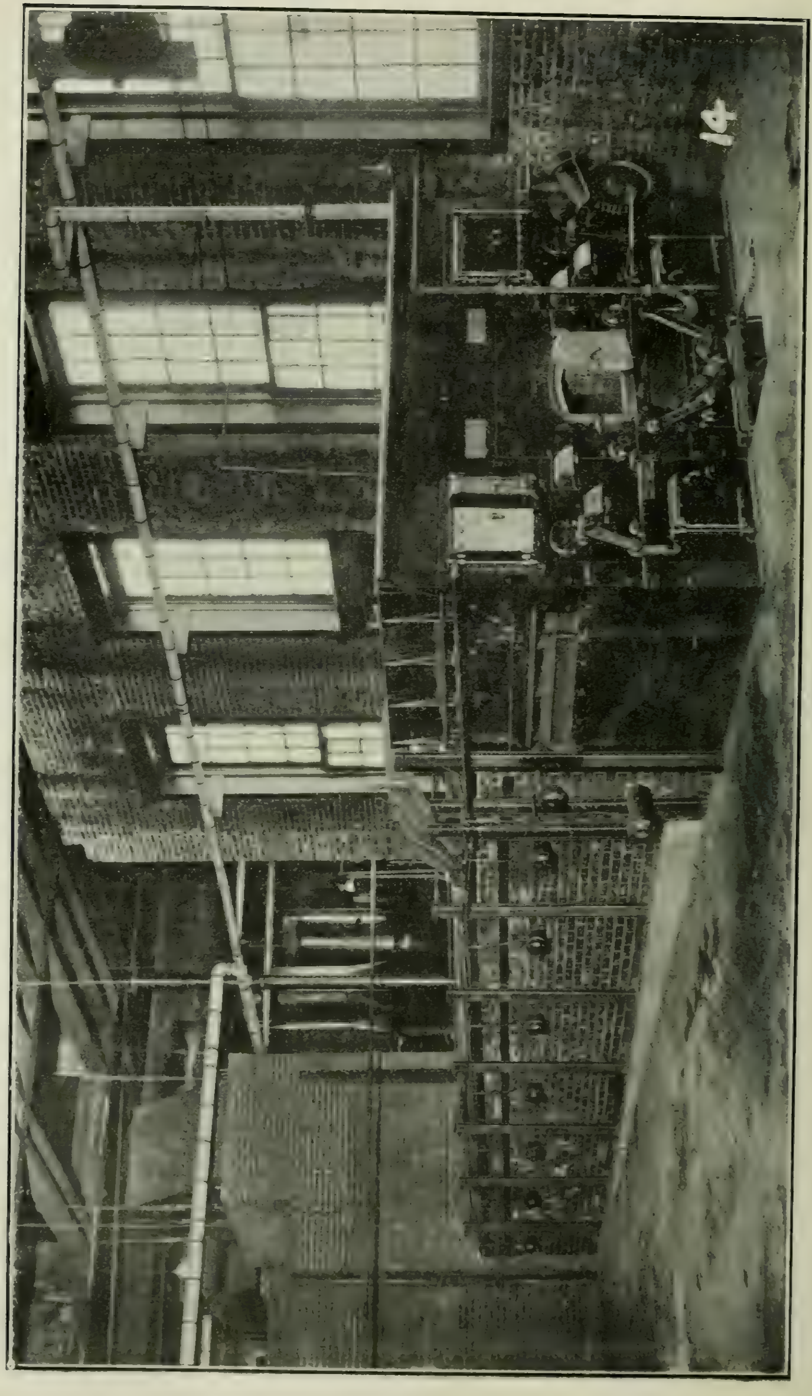
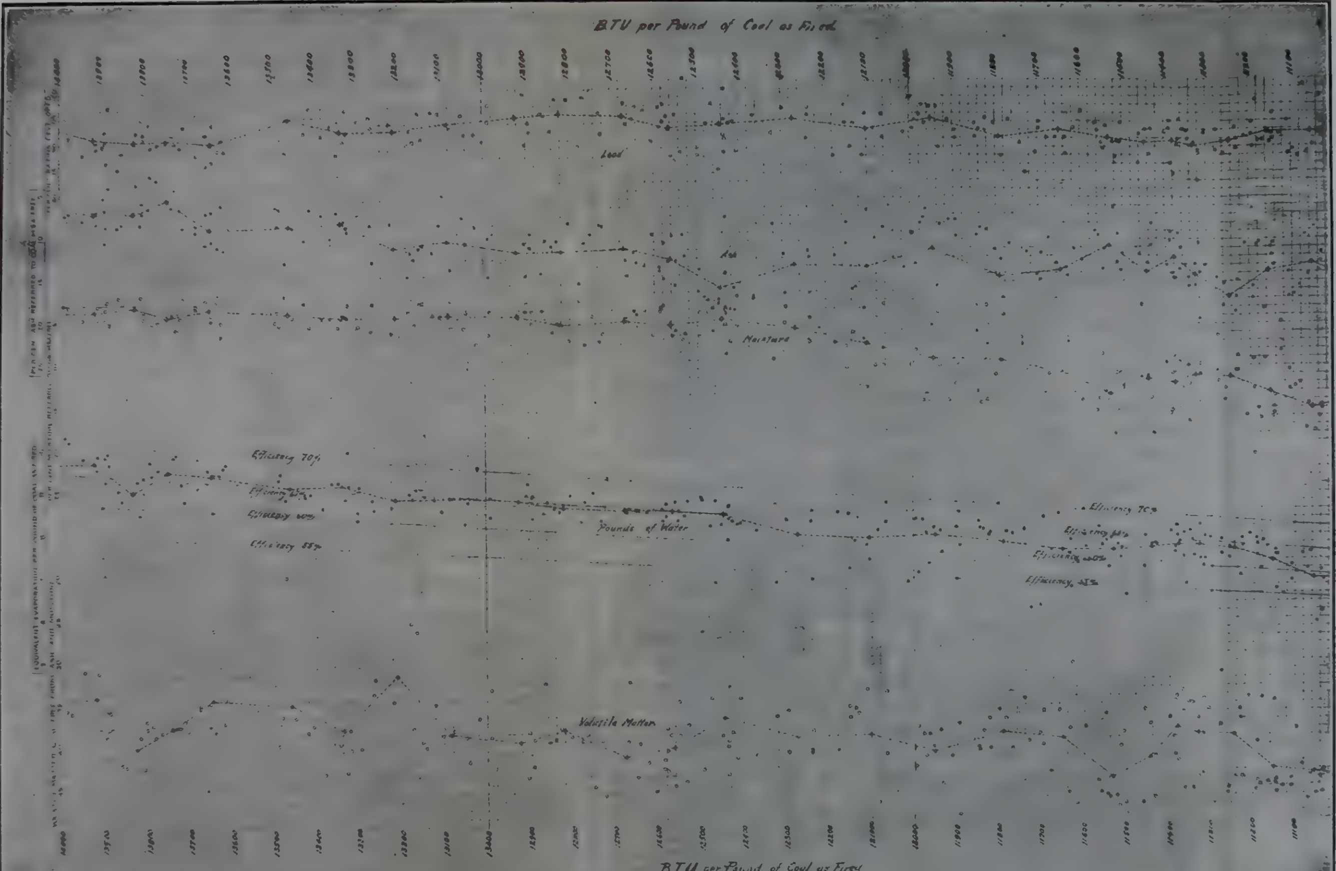


Plate B.



U.S.G.S. TESTS ON HEINE BOILER.
ST. LOUIS MO.

Mr. H. F. Dunham: What quantity of coal was burned in providing the data for different diagrams?

Mr. S. B. Flagg: I assume you mean the quantity burned during the different tests. Ordinarily, this amount was about four tons to a test.

Mr. E. M. Nichols: What was the maximum rate of combustion obtained?

Mr. S. B. Flagg: The maximum rate of combustion was approximately thirty-five pounds (of coal as fired) per square foot of grate surface per hour.

Mr. E. M. Nichols: If he got thirty-five pounds per hour maximum, he was getting very good work no difference what the apparatus was.

SMOKE AND SMOKE PREVENTION

BY L. P. BRECKENRIDGE

The problem of smoke prevention during the last few years has been one of increasing importance, and substantial progress has been made in its solution. The time will soon come, if not already at hand, when no power plant can offer as an excuse for a smoky chimney the plea that no appliances are available which can be depended upon for smoke prevention. The problem of smoke prevention is the problem of perfect combustion; there is no such thing as smoke consumption and this term should never be used. There is such a thing as perfect combustion and this means smokeless combustion.

THE PRINCIPLES OF SMOKELESS COMBUSTION

The subject of combustion should be familiar to all mechanical engineers. However, as a basis for a thorough understanding of the problems of smoke prevention, a brief review of the principles of combustion may prove acceptable in connection with this subject. In fact, the complete solution of the smoke problem consists in providing furnaces, so constructed and so capable of operation as to make combustion nearly perfect.

Combustion may be defined as a rapid chemical combination, resulting in heat and light. The combining elements are: (*a*) Oxygen, which is usually derived from atmospheric air; (*b*) Either carbon or hydrogen, or a compound of the two. Sulphur sometimes appears with carbon and hydrogen, and also combines with oxygen. The substance that is formed by the chemical union is called the product of combustion; and the heat that is produced by the combustion of a unit weight (one pound) of the fuel is called the heat of combustion. This is usually measured in British thermal units (B. t. u.). One B. t. u. is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. The following table relates to the complete combustion of hydrogen, carbon and sulphur:

Complete Combustion of Three Elements

Element	Chemical Symbol	PRODUCT OF COMBUSTION Name	Chemical Symbol	Heat of Combustion B. t. u. per lb.
Hydrogen ...	H	Water	H_2O	62000
Carbon......	C	Carbon Dioxide	CO_2	14500
Carbon......	C	Carbon Monoxide	CO	4400
Sulphur	S	Sulphur Dioxide	SO_2	4000

In the complete combustion of carbon, the product of combustion, it will be observed, is carbon dioxide (CO_2). Each atom of carbon combines with two atoms of oxygen. If sufficient oxygen is not provided, it may happen that each carbon atom will combine with but one oxygen atom, thus forming carbon monoxide (CO). As a result of this incomplete combustion, the heat developed is only 4400 B. t. u. The carbon monoxide may itself combine with oxygen, according to the formula

$$CO + O = CO_2$$

and the heat developed will be the difference, 14 500 — 4400 = 10 100 B. t. u. per pound of carbon in the carbon monoxide.

A knowledge of the relative weights of these elementary atoms gives a direct means of computing the amount of oxygen required for combustion. The weights are as follows:

H..........	1	O...........	16
C..........	12	S..........	32

In the burning of hydrogen to H_2O, two atoms of hydrogen, each of weight 1 combine with one atom of oxygen, weight 16; hence the ratio of oxygen to hydrogen is $16:2 = 8:1$, i. e., 8 lb. of oxygen are required for the combustion of 1 lb. of hydrogen, and there results $8 + 1 = 9$ lb. of water. This combination with others may conveniently be presented in a tabular form as follows:

The Combustion of Important Elements with Oxygen

ELEMENTS	CHEMICAL EQUATION	RELATIVE WEIGHTS	WEIGHTS POUNDS
Hydrogen to H_2O	$2H+O = H_2O$	$(2\times1)+16 = 18$	$1+8 = 9$
Carbon to CO_2	$C+2O = CO_2$	$12+(2\times16) = 44$	$1+2\frac{2}{3} = 3\frac{2}{3}$
Carbon to CO	$C+O = CO$	$12+16 = 28$	$1+1\frac{1}{3} = 2\frac{1}{3}$
Sulphur to SO_2	$S+2O = SO_2$	$32+(2\times16) = 64$	$1+1 = 2$
Methane or Marsh Gas	$CH_4+4O =$ CO_2+2H_2O	$(12+4)+(4\times16). =$ $12+(2\times16)+2(2+16)$	$1+4 = 2.75$ $+2.25$

When the oxygen needed for combustion is taken from the atmosphere, the nitrogen always present must be taken into consideration. Nitrogen takes no part in the combustion but mingles with the products of combustion, absorbs heat from them and passes away with them. Approximately, it takes 4.25 lb. of air to furnish 1 lb. of oxygen; the remaining 3.25 lb. are nitrogen. When the combustion of the different elements takes place in air the resulting relative weights are modified on account of the presence of the nitrogen. This is exhibited below.

The Combustion of Important Elements in Air

ELEMENTS	CHEMICAL EQUATION	RELATIVE WEIGHTS	WEIGHTS POUNDS
Carbon in Air	$C+Air =$ $CO_2+7.43N$*	$12+(2\times4.25\times16) =$ $44+104$	$1+11.33 =$ $3.67+8.66$
Marsh Gas in Air	$CH_4+Air =$ $CO_2+2H_2O+14.86N$	$(12+4)+(4\times4.25\times16) =$ $44+(2\times18)+208$	$1+17 =$ $2.75+2.25+13$

*The atomic weight of nitrogen is 14

It will be seen from the above table that to burn 1 lb. of carbon 11.33 lb. of air must be supplied. The 8.66 lb. of nitrogen contained in the weight of air pass away with the 3.67 lb. of carbon dioxide (CO_2) formed by the combustion. For the complete combustion of 1 lb. of marsh gas, 17 lb. of air are required. Chemical combinations of carbon and hydrogen, the so-called hydrocarbons, play an important part in the burning of coal, particularly in those coals of large volatile content. The most important of these are the following:

HYDROCARBON ELEMENT	CHEMICAL SYMBOL	HEAT OF COMBUSTION
Methane or Marsh Gas.....	CH_4	24020 B.t.u.
Ethylene or Olefiant Gas ...	C_2H_4	21930 B.t.u.
Acetylene................	C_2H_2	21850 B.t.u.

At the ordinary temperature and atmospheric pressure, a pound of air has a volume of about 13.1 cu. ft. Using this value the following (round numbers) are obtained for the theoretical amount of air required for the complete combustion of various fuels:

Amount of Air Required to Burn One Pound of Various Fuels

KIND OF FUEL	CARBON	HYDROGEN	SULPHUR	METHANE
Weight of Air (lb.)	11.33	34	4.25	17
Volume of Air (cu. ft.)	150	445	55	220

The heat developed by the combustion is absorbed by the products of combustion, and as a result, the temperature of these gases rises in a marked degree. Thus when carbon is burned in air, the 14 500 B. t. u. developed should heat the $3\frac{2}{3}$ lb. of CO_2 and $8\frac{2}{3}$ lb. of nitrogen from an initial temperature of perhaps 60° to a calculated final temperature of about 4500°. The actual final temperature, for reasons to be explained presently, is considerably lower. The products of combustion act as a vehicle, carrying the heat developed by combustion to its final destination.

It may perhaps be profitable to picture an ideal perfect combustion, and then inquire in what ways actual combustion falls short of the ideal. The given fuel, composed of carbon, various volatile hydrocarbon gases, and perhaps sulphur, is to be burned in air. Theoretically, each atom of the fuel finds and seizes upon the number of oxygen atoms with which it will combine. Each atom will meet with two oxygen atoms at a temperature sufficiently high for ignition. They will combine, and the resulting CO_2 will pass out of the furnace, carrying with it the heat arising from the combustion; likewise with the hydrogen and sulphur atoms. No more air will be delivered than is just sufficient to furnish the exact number of oxygen atoms, and no carbon or hydrogen atoms will pass out of the furnace without finding oxygen atoms with which they can combine.

Actual combustion deviates from ideal conditions in many respects. If only the theoretical amount of air is supplied, on account of the difficulty of properly mingling the fuel and air, some of the fuel atoms will not find oyxgen atoms, and will escape uncombined. Or some of the carbon may burn to carbon monoxide instead of to carbon dioxide, and the CO will escape without further combustion. It is found in practice that to insure complete combustion, an excess of air must be furnished. This excess is usually 50 per cent, and may reach 100 per cent; *i. e.*, while only 11.3 lb. of air are required for the complete combustion of 1 lb. of carbon, it is usually necessary to furnish 18 to 24 lb. Since the heat of combustion is distributed throughout the excess of air introduced into the furnace as well as the products of combustion, the furnace temperature is lowered by the presence of the extra air.

In another important particular, the actual state of affairs is likely to be quite different from the ideal combustion outlined above. Carbon and oxygen atoms will not unite unless a certain temperature, the ignition temperature, is reached. In parts of the furnace the temperature may fall below the ignition point because of the inrush of an excess of air, or because of cold bounding surfaces. As a result, carbon particles, even in the presence of plenty of oxygen, will refuse to burn. Let us further illustrate these principles by the use of some familiar examples.

If the reader understands why a torch smokes, why a flat wick is used in a lamp, why a circular burner is provided for the Argand or student lamp, why a chimney is provided for oil lamps, why a fish-tail flame was used in early gas lighting, or why a vacuum bulb is provided for the incandescent lamp; if he understands these things, and most of us do, he will, it is believed, be able easily to see what conditions are necessary for perfect combustion in boiler furnaces.

If any fuel is to be burned without smoke it must be supplied with the correct amount of air. The torch smokes because the large round wick brings up oil, especially in the center, to which air cannot be supplied. If the air supply through the center tube of our student lamp is shut off a smoking flame results. The candle with the small wick is an advance over the candle supplied with the large wick. The flame from the flat wick has an extended surface for air supply, while the circular burner not only has maximum surface for air supply, but the air coming up through the center of the tube is heated, making it still better suited to aid combustion and burn a large amount of oil. Thus it is that we have successfully solved the problem of burning a large supply of oil without smoke. If we try to increase the oil consumption and turn up our lamps too high, they smoke, and because they are in the room with us we immediately turn them down. Furnaces burning coal sometimes smoke just because they are forced too hard, and because the top of the chimney is not in our room, but in the public's pure air we do not turn them down, but let them smoke.

Air correct in amount is a necessity for complete combustion and the simple experiments which we have all been making with our oil and gas flames should be sufficient evidence to us that only when we are able to supply our furnaces with the correct amount of air shall we be able to control the smoke which it is so easy to make. How much easier our problem would be if, as in the lamp, we could see all that was taking place and could regulate all by a simple knurled brass handle.

SMOKE PRODUCTION

Having briefly outlined the essential features of perfect combustion let us turn our attention to the conditions present when the combustion is imperfect, usually resulting in smoke. The products of combustion, carbon dioxide, steam and sulphur dioxide, are colorless gases. If nothing except these gases escaped from a chimney, there would be no smoke problem. Visible smoke is due to the volatile hydrocarbons which all bituminous coal contains to a greater or less extent, and which are driven off when the coal is heated. The percentage of volatile matter in coal varies widely; thus in the eastern anthracites, it may be as low as 3 per cent, while in the western lignites, it may rise as high as 50 per cent. The larger the percentage of volatile matter, the more liable is the coal to produce smoke, and the more difficult is smoke prevention.

When coal is heated in the furnace, the volatile content, consisting largely of methane and ethylene, is driven off. If the volatile gases should not enter any region of high temperature, they would simply pass out of the chimney with the products of combustion. But, as a rule, the gases are ignited, and burn, much as ordinary illuminating gas burns. The phenomena connected with the combustion of volatile gases are, however, not simple. There are grounds for supposing that a hydrocarbon, at a sufficiently high temperature, is decomposed into its elements. If oxygen is present, the hydrogen at once combines with it. The carbon particles will not combine with oxygen except under favorable conditions; if there is not a sufficient supply of air, or if it is not at a sufficiently high temperature, the carbon particles refuse to combine and are carried along with the products of combustion to be afterwards deposited as soot, or appear at the top of the chimney as smoke. This may be shown by an equation as follows:

$$C_2H_4 + 2\,O = H_2O + 2\,C$$

Ethylene and oxygen form water vapor and soot.

The mere explanation of the formation of black smoke suggests immediately the means that should be employed to prevent such formation. Evidently sufficient air must be furnished to burn the carbon particles liberated from the hydrocarbon gases; this air must be at a high temperature. If too great a volume of cold air is admitted to the furnace, and if at the same time the bounding surfaces of the combustion space are boiler plates or tubes of relatively low temperature, the result will be a low temperature in the space above the fuel, and it will be impossible to burn the carbon content of the volatile matter. To insure proper combustion, after the gases are driven from the coal, they should intimately mingle with sufficient air in a chamber, in which high temperature can be maintained. The heating suface of the boiler should not be permitted to come in contact with these gases until combustion has been completed.

THE OBSERVATION OF SMOKE

From the point of view of the general public there are but two kinds of chimneys, those that smoke and those that do not smoke. The emission of black smoke for a short period, say of three minutes of an hour is sometimes enough to leave the impression on the casual observer that the chimney smokes all the time. It is therefore important that there should be some way devised for estimating the relative blackness of smoke and some plan adopted for recording the length of time during which smoke of varying degrees of blackness is emitted from chimneys. Numerous schemes have been proposed to accomplish this purpose. One of the most scientific of these plans is that invented by Professor Ringelmann of Paris.*

> In making observations of the smoke proceeding from a chimney, four cards ruled like those in the cut (see Fig. 1), together with a card printed in solid black and another left entirely white, are placed in a horizontal row and hung at a point about 50 feet from the observer and as nearly as convenient in line with the chimney. At this distance the lines become invisible, and the cards appear to be of different shades of gray, ranging from very light gray to almost black. The observer glances from the smoke coming from the chimney to the cards, which are numbered from 0 to 5, determines which card most nearly corresponds with the color of the smoke, and makes a record accordingly, noting the time. Observations should be made continuously during say one minute, and the estimated average density during that minute recorded, and so on, records being made once every minute. The average of all the records made during a boiler test is taken as the average figure for the smoke density during the test, and the whole of the record is plotted on cross-section paper (see Fig. 2), in order to show how the smoke varied in density from time to time. A rule by which the cards may be reproduced is given by Professor Ringelmann as follows:
>
> Card 0. All white.
> Card 1. Black lines 1 mm. thick, 10 mm. apart, leaving spaces 9 mm. square.
> Card 2. Lines 2.3 mm. thick, spaces 7.7 mm. square.
> Card 3. Lines 3.7 mm. thick, spaces 6.3 mm. square.
> Card 4. Lines 5.5 mm. thick, spaces 4.5 mm. square.
> Card 5. All black.
>
> The cards as printed on p. 14 are much smaller than those used by Professor Ringelmann. The thickness and spacing of the lines are in the same proportion, but reduced to one-half size.

The smoke observations reported in the government fuel tests made by the Technologic Branch of the U. S. G. S. are all based on the Ringelmann chart. This chart has, therefore, been adopted in the reports of fuel tests made by the Engineering Experiment Station and the numbers used in its bulletins refer to this scale.

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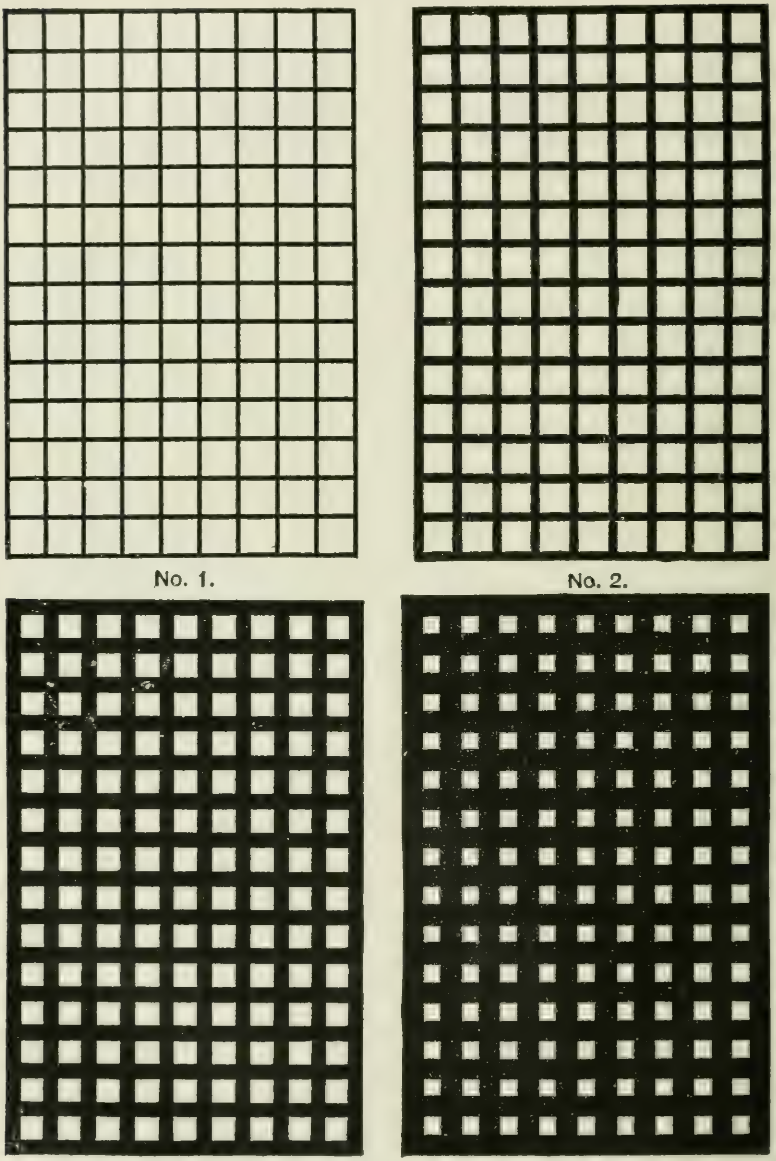
*Trans. A. S. M. E., vol. xxi, Dec. 1899.



No. 1.

No. 2.

No. 3.

No. 4

FIG. 1 THE RINGELMANN SCALE FOR GRADING THE DENSITY OF SMOKE

An observer soon becomes skilled in taking smoke records and when several observers have been trained to the system their records are very nearly alike. In fact one soon becomes so familiar with the scale of densities that he no longer needs the actual charts for comparison, but may be trusted to take the record without the aid of the chart. An attempt has been made to illustrate smoke densities in the plate shown in Fig. 2. Many difficulties surrounded the preparation and printing of such a plate and it is inserted with some misgivings. It is believed, however, that if it should prove successful it will give some readers a better idea of the value of the scale numbers 1 to 5, used to denote smoke densities, than will the pictures of the Ringelmann charts.

When a record of a smoking chimney is desired, numerous ways are adopted for showing its behavior. For many records a column of the scale density numbers is sufficient, set of course opposite the intervals of time which are deemed short enough for the purpose for which the observations are taken. Where many records must be taken the work may be facilitated by using some of the simple mechanical devices which have been perfected for this purpose. These usually consist of a drum rotated by clockwork, and a marking pen movable by hand leaving a record on suitable paper that has been wrapped on the drum. The form of smoke chart record adopted in the work of the Engineering Experiment Station is shown in Fig. 3. This form needs little explanation. The scale density numbers are those at the left of the sectioned plates and these densities are approximately shown at the top under their respective numbers. It is intended that the time scale shall be chosen and placed along the zero horizontal lines. This time scale will vary according to the character of the tests being made. Graphic charts are for many purposes much preferable to any other scheme for exhibiting the continuous operation of chimneys supposed or claimed to be smokeless, and they are particularly useful when comparing several stacks for the same interval of time, or when changes made in a setting are being studied.

FURNACES AND BOILER SETTINGS

General Principles of Construction.—Various writers on boilers and furnaces have enunciated the principles of smoke preven-

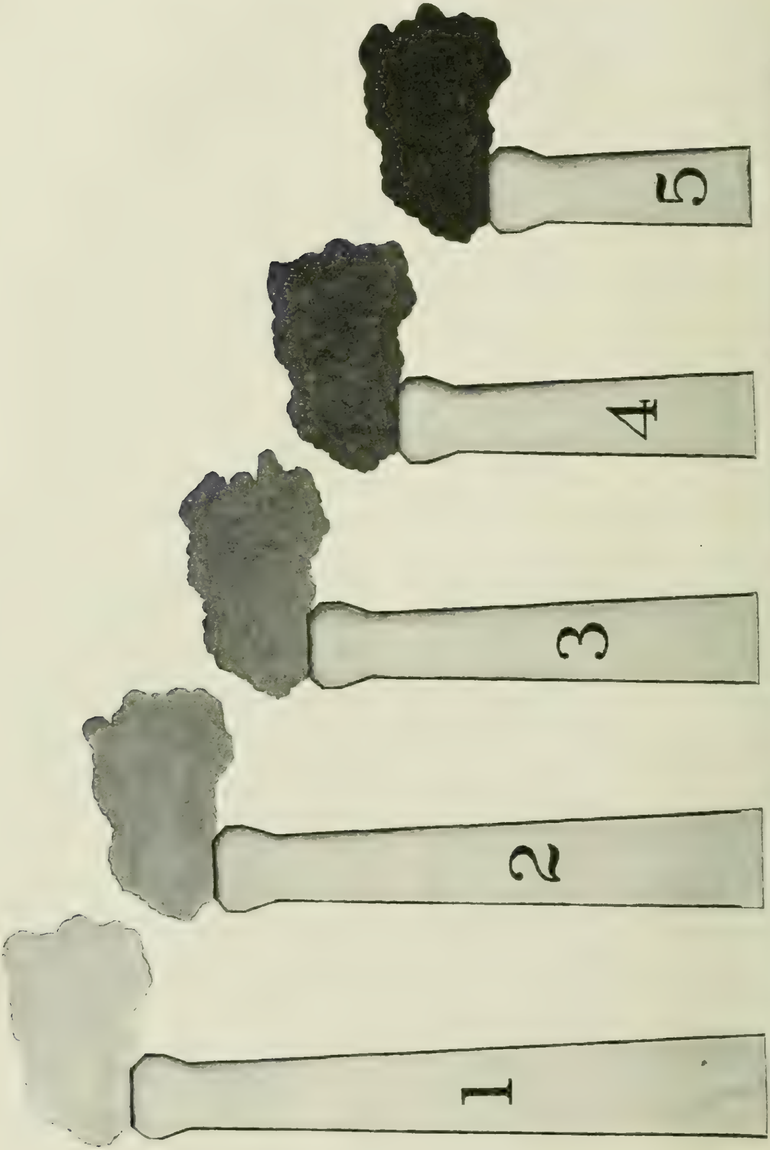


FIG. 2 CHIMNEYS ILLUSTRATING SMOKE DENSITIES APPROXIMATING THE RINGELMANN SMOKE CHARTS

tion in different ways. In "Steam Boiler Economy," Wm. Kent says:

> Coal can be burned without smoke provided:
>
> (*a*) The gases are distilled from the coal slowly.
>
> (*b*) That the gases when distilled are brought into intimate contact with very hot air.
>
> (*c*) That they are burned in a hot fire-brick chamber.
>
> (*d*) That while burning they are not allowed to come in contact with comparatively cool surfaces, such as the shell or tubes of a steam boiler; this means that the gases shall have sufficient space and time in which to burn before they are allowed to come in contact with the boiler surfaces.

Mr. A. Bement, who has made a careful study of the smoke problem, suggests* some slight modifications of the Kent form of statement. He says:

> Professor Kent's requirements may be modified as to two features as follows:
>
> (*a*) That the evolution of gas from the coal shall proceed uniformly.
>
> (*b*) That the gases which are distilled uniformly from the coal shall enter a fire-brick chamber of either sufficient length to allow the flames to become entirely consumed naturally or that the chamber be provided with such auxiliary mixing and baffling devices as will cause the gases to be artificially mixed together before the exit of the chamber is reached.

Further discussing the subject, Mr. Bement presents clearly the importance of uniformity of the evolution of the volatile gases and points out that the lack of uniformity of the evolution of the gases when coal is hand-fired must be supplemented by efficient mixing devices such as fire-brick piers or special baffling.

Any fuel may be burned economically and without smoke if it is mixed with the proper amount of air at a proper temperature.

This is the statement of the smoke problem that the writer has sometimes presented. We have then three forms of presentation of the problem. To the fuel expert any one of these forms is sufficiently clear. It does, however, require some familiarity with the problem to understand just what these statements mean. To the owner who is trying to make his plant stop smoking or who must decide between several types of furnaces or boilers that he wishes to install, all these carefully stated formulas are often meaningless and provoking. What the owner wishes to know is what furnaces and boilers are in the market that are really suitable for burning bituminous coals without smoke. It is in many ways unfortunate that there are so many independent manufacturers of furnaces and boilers. Both furnace and boiler should preferably be sold and installed by the same company. It may not be long before this will be so. At least, the boiler companies should furnish complete plans with their boilers including the furnace. Possibly this matter might be left to the consulting engineers, but many firms buy their boilers directly from the boiler companies and follow the same setting plans that have been developed and found efficient with anthracite or other eastern coals, and often these are entirely unsuited for coals having a high volatile content.

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*The suppression of Industrial Smoke with Particular Reference to Steam Boilers.—Journal Western Society of Engineers. Dec., 1906.

The Peabody Atlas—Shipping Mines and Coal Railroads in the Central Commercial District of the United States, with Chemical, Geological and Engineering Data. A. Bement, 1906. 16¾ x 18 in. 149 pp. An extensive and valuable work relating to the central coal fields of the United States, published by the Peabody Coal Co., Chicago. The section devoted to smokeless furnaces and smoke suppression contains many excellent illustrations which should be of great help to engineers who wish to be fully informed on this subject.

Much confusion has doubtless arisen and many disappointments have followed because of the fact that furnaces found entirely suitable for eastern coals have been tried further west without modification and have proved themselves failures. Some of the furnaces described in this paper would not be suitable for use with eastern coals. The use of the Dutch oven furnace, which was common before the chain grate stoker, doubtless paved the way for the various forms of automatic stokers which made use of the good points recognized in the old forms of the Dutch oven furnaces.

The history of the growth and development of the smokeless furnace could well form the subject for an engineering article. It is hoped that some one may soon make the steps in such a development a matter of record. The writer certainly makes no claims for discovery or invention in this connection. He has, however, experimented with many methods of firing, many devices for smoke prevention and many variations in furnace construction, not only in Illinois, but also in Pennsylvania and in New England.

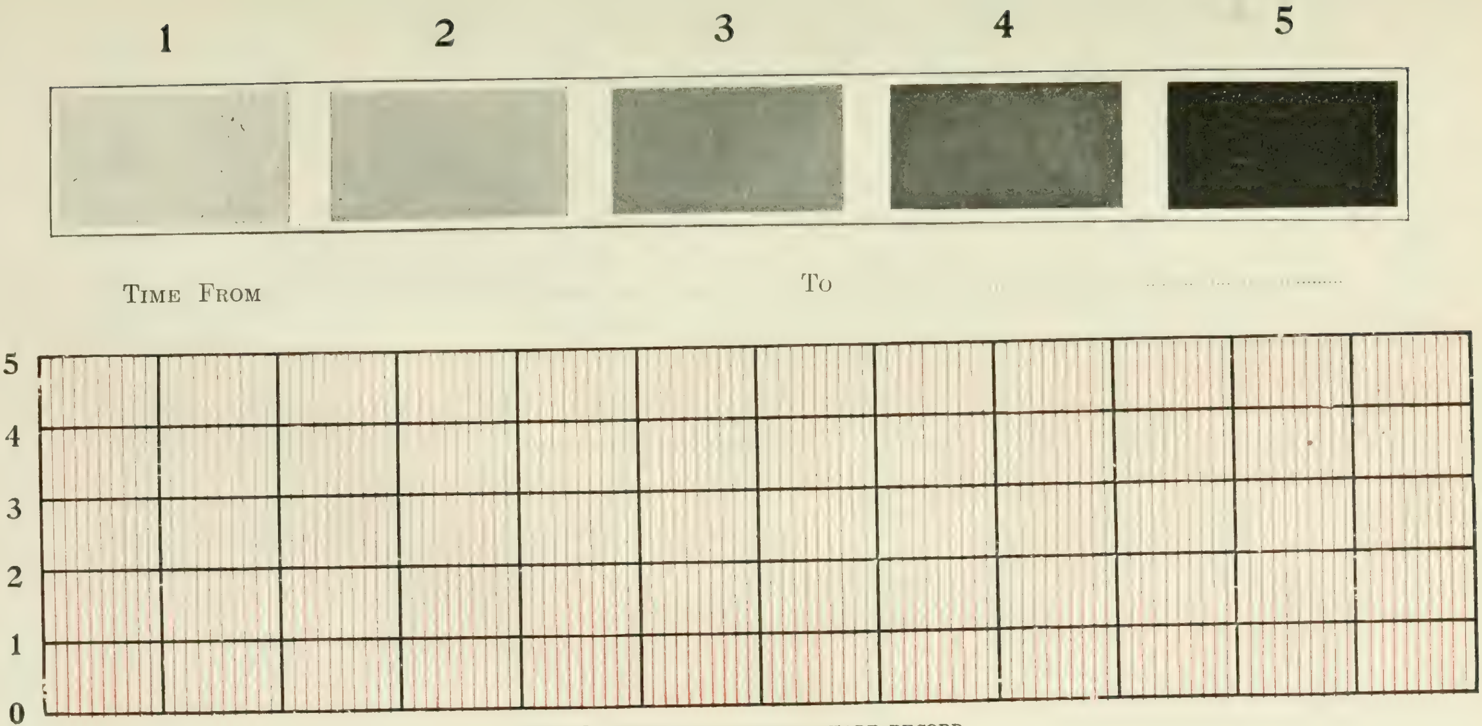

FIG. 3 SECTION OF SMOKE CHART RECORD

The boiler plant at the University of Illinois at Urbana, Illinois, consists of 2000 horse-power in nine units. During the last two years this plant has been operated practically without objectionable smoke fully 90 per cent of the time. Over 200 separate boiler tests have been made in this plant to determine the economy of operation and for a study of furnace conditions. Many changes have been made in the constructive features of the furnaces and boiler baffling with the view of studying the smoke problem. Many varieties of coal have been tested for smokelessness. The character of the installation is indicated below.

Boiler No. 1. Babcock & Wilcox (special high-pressure boiler, 275 lb.), equipped with B. & W. chain grate stoker, usual vertical baffling, capacity 150 H. P. This unit can be run without smoke at capacities from 50 to 120 per cent.

Boiler No. 2. Babcock & Wilcox standard boiler (150 lb.), equipped with B. & W. chain grate stoker, usual vertical baffling, capacity 150 H. P. This unit can be run without smoke at capacities from 50 to 120 per cent.

Boiler No. 3. Stirling standard boiler (150 lb.), equipped with Green chain grate stoker, usual baffling and combustion arches, capacity 260 H. P. Setting shown in Fig. 4. This unit can be run without smoke at capacities from 50 to 140 per cent.

Boiler No. 4. National water tube boiler (150 lb.), formerly equipped with Murphy furnace but now equipped with Green chain grate stoker, usual vertical baffling, capacity 250 H. P. This unit can be run without smoke at capacities from 50 to 120 per cent. When equipped with Murphy furnace, this unit was smokeless except when cleaning fires.

Boiler No. 5. Babcock & Wilcox standard boiler (150 lb.), equipped with Roney stokers, usual vertical baffling, capacity 220 H. P. Setting shown in Fig. 5. This unit when handled carefully can be run up to capacity without smoke above No. 2 on the smoke chart. It requires careful attention and at capacities above 100 per cent cannot be run without objectionable smoke. This boiler is an exact duplicate of unit No. 6.

Boiler No. 6. Babcock & Wilcox standard boiler (150 lb.), equipped with Roney stokers, special baffling, making

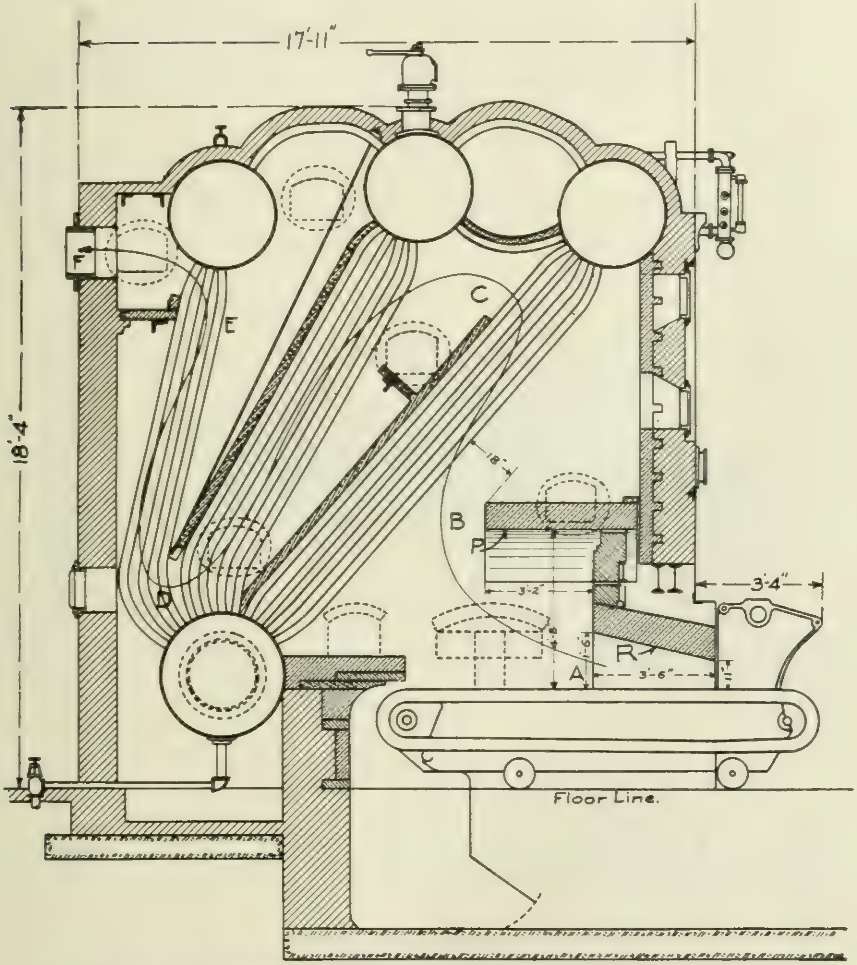

FIG. 4 STIRLING STANDARD 260 H.P. BOILER EQUIPPED WITH CHAIN GRATES
(Operate easily without smoke at capacities from 50 to 140 per cent)

tile-roof furnace. Boiler and stoker duplicate of unit No. 5. Capacity 220 H. P. Setting shown in Fig. 6. This unit can be run without smoke at capacities from 50 to 100 per cent.

Boiler No. 7. Stirling standard boiler (150 lb.), equipped with Stirling bar grate stoker, usual baffling and combustion arches, same as boiler No. 3, capacity 260 H. P. This unit can be run without smoke at capacities from 50 to 140 per cent.

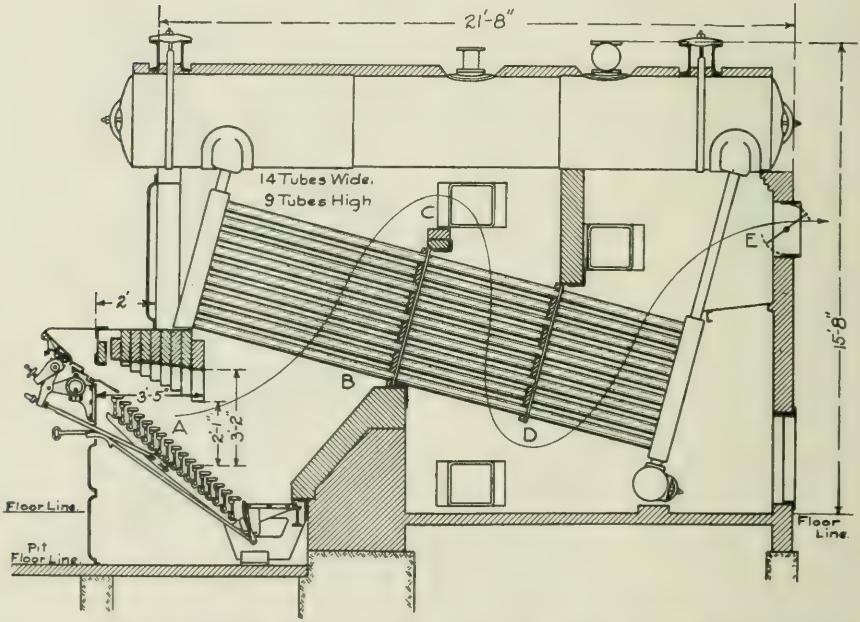

FIG. 5 BABCOCK & WILCOX 220 H. P. BOILER EQUIPPED WITH RONEY STOKERS, USUAL VERTICAL BAFFLING

(With careful handling may be run up to capacity without smoke above No. 2 on Smoke Chart; above 110 per cent capacity cannot be run without objectionable smoke except by expert firemen)

Boiler No. 8. Stirling standard boiler (150 lb). Exact duplicate of boiler No. 7, capacity 260 H. P.

Boiler No. 9. (Engineering Experiment Station special test boiler), Heine standard boiler (150 lb.), equipped with

Green chain grate, usual combustion arch, tile-roof furnace, adjustable water back at bridge wall, capacity 210 H. P. Setting shown in Fig. 7. This unit can be run without smoke at capacities from 50 to 140 per cent.

A study of the various units mentioned above reveals the fact that any of the four well-known types of boilers may be set over at least three well-known types of automatic stokers and be operated without objectionable smoke. The opinion of the writer, doubtless held by most engineers, is that the boiler has very little to do with the smoke problem, except perhaps that some types of boilers lend themselves more easily to the necessary furnace construction, which is of the utmost importance when perfect combustion is desired.

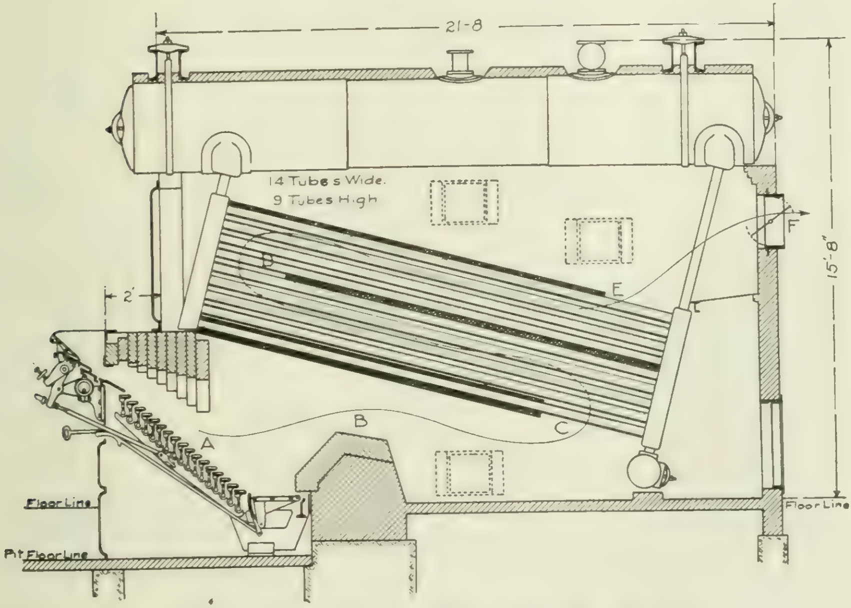

FIG. 6 BABCOCK & WILCOX 220 H. P. BOILER EQUIPPED WITH RONEY STOKER
(Setting as in Fig. 2, but arranged with different baffling, forming a tile roof furnace. This unit can be run at capacities from 50 to 100 per cent without smoke)

DESCRIPTION OF THE SETTINGS SHOWN BY THE FIGURES

In the figures which accompany this article there are shown several types of boilers and furnaces that have been found suitable for burning bituminous coals without smoke. These settings have been operated under the immediate observation of the writer. Each figure is supplied with a title which is at the same time a description of the setting and an indication of the possibility of its smokeless operation under varying conditions of service. The drawings themselves are sufficient to illustrate the conditions that must be fulfilled to secure smokelessness when using boilers of these types under usual service capacities. The stack draft available for boilers No. 1 to 8 is 0.75 in. to 1 in., supplied by a brick chimney 150 feet high with an inside diameter of 6 feet. Boiler No. 9 is supplied with an economizer and an induced draft fan permitting higher rates of combustion than are possible in the other settings.

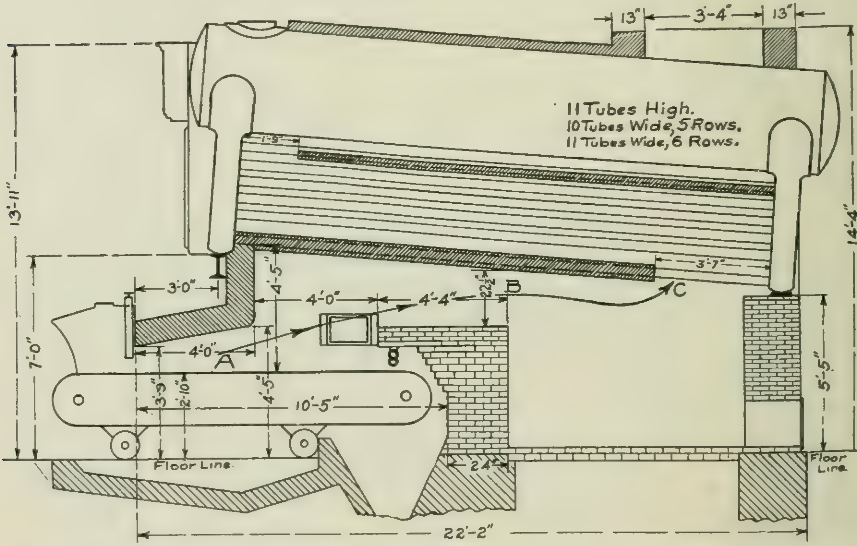

FIG. 7 HEINE STANDARD 210 H. P. BOILER EQUIPPED WITH GREEN CHAIN GRATE, COMBUSTION ARCH, TILE ROOF FURNACE, ADJUSTABLE WATER-BACK AT BRIDGE WALL

(This is the Engineering Experiment Station boiler furnished with induced draft. It can be run easily without smoke at capacities from 50 to 140 per cent; almost impossible to make smoke with this setting under any condition of operation)

In all of these settings it has been found necessary to pay particular attention to the coking arch under which the fresh charge of coal is being delivered. It seems to be true that over chain grates this arch should be inclined upwards more for a light than for a heavy draft. It is also believed that the arch of the Roney stoker should be kept well down toward the grates. The dimensions given in Fig. 5 have given good results in these settings.

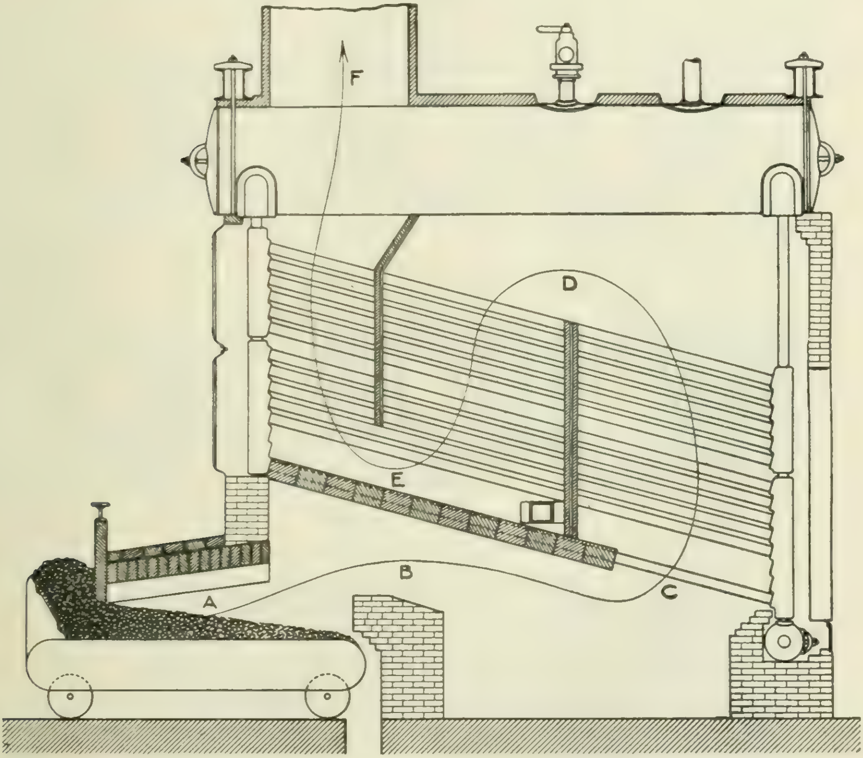

FIG. 8 SMOKE-PROOF STEAM GENERATOR DESCRIBED BY A. BEMENT, IN THE PROCEEDINGS OF THE WESTERN SOCIETY OF ENGINEERS, OCTOBER, 1906

(A satisfactory plan when proper attention is given to the draft available and to the areas of the gas passages)

When coal is being burned in any furnace it is essential that the volatile products of combustion should be uniformly distilled from the coal and mixed with sufficient air at a high temperature. To accomplish this, particularly to maintain a high temperature, the mingling air and products of combustion must be kept away from the tubes or plates of the boiler which are comparatively cool, and which would therefore cool the gases before complete combustion had taken place. It is for the reason just mentioned that such forms of furnaces as shown in Figs. 6, 7, and 8 are planned. Special forms of fire-clay tile are designed to be hung on the water tubes of boilers that are directly over the fire. The tiles form the roof of the furnace and prevent the hot gases, which are still not properly mixed, from coming in contact with the cooler tubes which are surrounded by the tiles. These tiles are made in various forms, three types being shown in Fig. 9. The kind shown at C makes a smooth flat roof for the furnace and has been found very satisfactory.

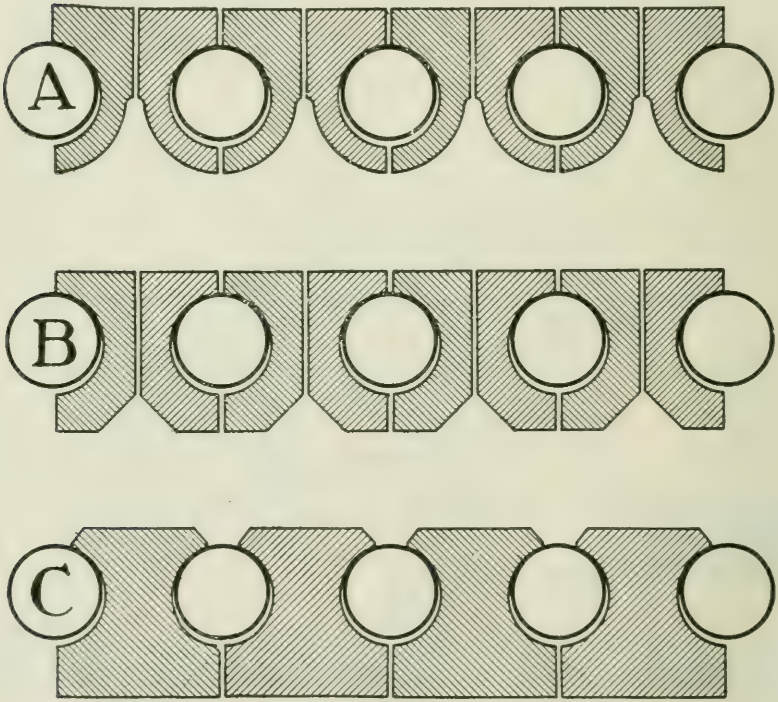

FIG. 9 THREE TYPES OF TILE ROOFS FOR BOILER FURNACES

The length of a tile-roof furnace or the distance of flame traveled before reaching the cool tube surface must evidently depend upon the total volume of volatile products distilled from the coal on the grate in a given time, which must be mixed with the air supply before the cooling tubes are reached. The higher the coal is in volatile content or the higher the rate of combustion per square foot of grate area, the longer will be this flame length. The coals that have been burned without smoke in the furnaces shown have had a combustible volatile content of from 30 to 40 per cent and they have been burned at a rate of from 16 to 40 lb. of coal per square foot of grate per hour. It will now be understood why such settings as shown in Fig. 5 cannot be depended upon for smokelessness. The cold tubes of the boiler are too near the flame, the temperature of the flame is reduced before combustion is complete and smoke results. There are coals low in combustile volatile matter that may easily be burned in such furnaces without smoke. In fact, when not forced, this furnace will burn many kinds of Illinois coals, but only with the greatest care have we been able to burn the usual grades of Illinois coals at desirable rates of combustion (24 to 30 lb.) without objectionable smoke (No. 2 to 3⅓ on the smoke chart).

When the baffling shown in Fig. 6 was installed a series of smoke trials was arranged with this setting and the setting shown in Fig. 5. The results shown by these trials were disappointing and unsatisfactory. Lack of sufficient draft made it impossible to run setting Fig. 6 above its rated capacity. Under this condition there was little difference in the smoke from the two furnaces. This result suggests that changes in baffling of existing plants must be made with careful consideration of draft areas available or capacities may be cut down to an undesirable extent. The capacity possible with the setting shown in Fig. 6 proved to be about 90 per cent to 98 per cent, while the capacity of the settings shown in Fig. 5 with the same coal was from 100 per cent to 120 per cent. The setting of Fig. 6 should prove satisfactory with higher draft pressures or by increased areas possible with a larger number of tubes in the vertical rows. From what has already been said about cool tubes, an inspection of the settings in Fig. 4, of a Stirling boiler over a chain grate stoker, might convey the impression that such a setting would produce smoke because of the absence of tile on the tubes below the path of the flame A B C. This setting has, however, proved to be a satisfactory and smokeless one. Looking at the progress of combustion through the side openings provided in the three settings of this character in the University plant, it is seen that the flame rolls along over the edges of the two arches shown and is by these arches completely mixed. No part of the tubes below the flame path A B C is enveloped by the flames; therefore the tubes have little cooling effect. It is also very evident that the lower ends of the tubes next the furnace fulfill their duty as heat transmitters by taking care of a very considerable part of the radiant heat which is available in large quantities at that point. Boilers of this type are now being manufactured at almost any desired height, the necessary capacity being furnished by increased width. They have proved very satisfactory, smokeless furnaces being easily arranged under them.

The Heine boiler set over a Green chain grate shown in Fig. 7 is the boiler installed by the Engineering Experiment Station for fuel tests with Illinois coals. This boiler is exactly like the Heine boiler used in the government fuel tests at St. Louis. In this setting, however, we have a stoker furnace while the government boilers were set with hand-fired furnaces, evidently necessary where coals from many sections of the country were to be tested. The setting shown in Fig. 7 is provided with an economizer and a large induced draft fan making high rates of combustion possible. This setting is smokeless under the many and varied conditions of operation which have thus far been applied to it. Over 100 trials of about 10 hours' duration of various kinds of bituminous coal have been made in this setting. In all of these trials the smoke record has been "No smoke all day." This is the setting to which the writer has referred in several recent talks by saying that in this setting it has been impossible to make smoke. In order to justify any such statement, attention is called to the results of a series of tests made with this setting for the express purpose of smoke production if such was possible under apparently adverse conditions.

Those who desire to grasp the simple yet fundamental principles of smokeless combustion for bituminous coals should thoughtfully consider just how this furnace fulfills the conditions of perfect combustion, as stated on page 15 in the words of Kent, Bement and the writer. A detailed account of the process in this furnace may well bear repetition here.

The fresh coal, fairly uniform in size, advances slowly from the hopper along on the grate toward the furnace where the temperature is very high. The combustible volatile matter is continually being distilled from the coal, more and more rapidly, but with much uniformity, while it is passing under the combustion arch. Some of the necessary air flows in through the coal in the hopper, more through the grate under the arch, but by far the most flows through the red-hot coals on that part of the grate beyond the arch. This air is thus heated and made ready for combining with the volatile products flowing from beneath the arch, and all together mix and roll along on the bottom of the tiles forming the roof of the furnace.

The bottom row of boiler tubes is covered with suitably formed tiles, which prevent the still actively mingling gases from being cooled by coming in contact with the tubes, and so the combustion processes go on until completed before reaching C, a point before the gases pass in among the cooling tubes. The tiles in the adjoining rows touch each other so that no gases pass between them. In such a furnace as this the smoke problem is settled somewhere between B and C. When the total volume of combustible material distilled from the coal is quite large in a given interval of time, the flame length may reach to C, while for smaller volumes the flame may end at B. Thus it is that the flame length indicates the end of the combustion processes and gives us valuable information concerning the proportions of smokeless furnaces.

It is important in the operation of this or any form of mechanical stoker that abundant opportunity be afforded for inspecting the condition of the fires and the progress of combustion. Appliances for continually indicating the composition of the escaping gases should be considered a necessity in all large and well-managed plants.

The character of the draft apparatus available with this setting made it possible to make sudden changes in the rate of combustion. The rate of travel of the chain grate was easily adjusted by a throttle governor on the independent steam engine in driving the grate. The rate of combustion could be calculated

TABLE 1

Special Smoke Tests of Illinois Coal with a Chain Grate Stoker, Tile Roof Furnace and Heine Water Tube Boiler, with Varying Rates of Combustion. February 5, 1907. Coal—Washed, Size No. 4a.

ITEM Test No.	1	2	3	4	5	6	7	8
Time, Start	8:10	9:00	9:30	9:56	1:00	1:30	2:00	2:35
Time, Stop	9:00	9:30	9:56	1:00	1:30	2:00	2:35	2:47
Thickness of Fuel Bed	4	4	4	4	4	4	4	4
Draft Pressure in Furnace	.092	.110	.180	.095	.098	.057	.050	.080
Draft Pressure in Breeching	.430	.600	1.260	.580	.500	.250	.090	.240
Lbs. Coal Fired per sq. ft. of Grate Surface per hour	31.4	39.3	45.5	——	35.8	28.3	23.4	——
Do. Dry Coal	27.8	34.8	40.4	——	31.7	25.5	20.7	——
Mean Per cent of Rated Capacity Developed	112	126	155	——	135	109	91	——
Flue Gas Temperature, F°	629	671	762	661	659	600	521	560
Temperature over Grate	2500	2550	2620	——	2530	2390	2310	——
Temperature Back of bridge Wall	2470	2550	2710	——	2490	2390	2310	——
Per cent CO_2	12.0	12.8	12.2	——	12.8	12.8	14.4	——
Smoke	0	½	1	0b	0	1½	2½	0

(*a*) Moisture in coal as fired, 11.3 per cent; ash, 7.5 per cent.

(*b*) Grate stopped for repairs.

TABLE 2

Special Smoke Tests of Illinois Coal with a Chain Grate Stoker, Tile Roof Furnace and Heine Water Tube Boiler, with Varying Rates of Combustion. February 9, 1907—Washed, Size No. 2.

ITEM Test No.	1	2	3	4	5	6	7	8
Time, Start	8:03	9:00	10:00	11:00	12:00	1:00	2:00	3:00
Time, Stop	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00
Thickness of Fuel Bed	6	6	6	6	6	6	6	6
Draft Pressure in Furnace	.126	.154	.178	.122	.12	.088	.060	.12
Draft Pressure in Breeching	.56	.73	.96	.56	.50	.23	.11	.350
Lbs. Coal Fired per sq. ft. of Grate Surface per hour	27.5	28.2	34.9	28.5	23.7	21.5	21.0	31.4
Do. Dry Coal	24.5	25.5	31.3	25.4	21.5	19.3	18.7	27.7
Mean per cent of Rated Capacity Developed	92	109	119	112	111	89	67	99
Flue Gas Temperature, °F	671	679	707	663	642	574	516	562
Temperature over Grate	2375	2485	2420	2340	——	2280	2235	2465
Temperature Back of Bridge Wall	2305	2385	2340	2360	——	2210	2090	2475
Per cent CO_2	10.1	10.1	9.1	10.0	9.8	11.6	11.4	11.8
Smoke	0	0	0	0	0	⅛	0	1½b

(*a*) Moisture in coal as fired, 11 per cent; ash 7.97 per cent.

(*b*) Much unconsumed coke forced over back end, thus increasing the ratio of volatile carbon in the fuel actually consumed.

TABLE 3

Special Smoke Tests of Illinois Coal with a Chain Grate Stoker, Tile Roof Furnace and Heine Water Tube Boiler, with Varying Rates of Combustion. February 11, 1907. Coal—1½ inch Screenings, Ordinary Grade for Tests, 1, 2, 3, 4, 5a. Poor Grade for Tests, 6, 7, 8.

ITEM / Test No.	1	2	3	4	5	6	7	8
Time, Start	8:05	9:00	10:00	11:00	12:00	1:00	2:00	3:00
Time, Stop	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00
Thickness of Fuel Bed	5	5	5	5	5	7	7	7
Draft Pressure in Furnace	.202	.252	.40	.23	.108	.302	.355	.58
Draft Pressure in Breeching	1.21	1.30	———	1.12	.23	1.48	1.21	———
Lbs. Coal Fired per sq. ft. of Grate Surface per hour	32.7	35.4	39.3	30.2	12.4	46.5	26.8	26.2
Do. Dry Coal	27.4	30.0	33.2	25.5	10.5	———	———	———
Mean per cent of Rated Capacity Developed	87	103	106	84	56	106	75	68
Flue Gas Temperature, °F	674	704	718	650	542	674	646	625
Temperature over Grate	2360	2400	2615	2489	2180	2530	2425	2485
Temperature back of Bridge Wall	———	———	———	———	———	———	———	———
Per cent CO_2	6.8	7.6	6.6	7.2	6.2	7.0	4.7	4.3
Smoke	0	0	0	0	0	0	0	0

(*a*) Moisture in coal as fired, 14.23 per cent; ash, 15.4 per cent.

TABLE 4

Special Smoke Tests of Illinois Coal with a Chain Grate Stoker, Tile Roof Furnace and Heine Water Tube Boiler, with Varying Rates of Combustion. February 12, 1907. Coal—1½-inch Screenings, selected a.

ITEM / Test No.	1	2	3	4	5	6	7	8
Time, Start	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00
Time, Stop	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00
Thickness of Fuel Bed	6	6	6	6	6	5	5	5
Draft Pressure in Furnace	.18	.25	.20	.10	.06	.195	.10	.05
Draft Pressure in Breeching	1.00+	1.5+	.93	.36	.21	1.20	.57	.15
Lbs. Coal Fired per sq. ft. of Grate Surface per hour	28.3	32	28.3	23.9	16.8	31.0	26.5	22.6
Do. Dry Coal	24.2	27.3	24.2	20.4	14.3	26.5	22.6	19.3
Mean per cent of Rated Capacity Developed	89.8	85	91	85	74	100	92	80
Flue Gas Temperature, °F	649	662	639	588	544	676	624	540
Temperature over Grate	2450	2525	2450	2435	2525	2305	2470	2490
Temperature back of Bridge Wall	———	———	———	———	———	———	———	———
Per cent CO_2	7	5.9	7	9.9	9.7	7.3	8.7	11.8
Smoke	0	0	0	0	0	0	0	0

(*a*) Moisture in coal as fired, 14.6 per cent; ash, 9.48 per cent.

very closely from the thickness of the fuel bed and the rate of grate feed, by reference to the large number of tests already made with this unit. These special smoke tests were run on four different days, and on each day eight changes in condition of operation were made. The thicknesses of fire used were four, five, six and seven inches. The capacities varied from 60 to 150 per cent of the rated capacity (210 H. P.) of the boiler. The character and the size of the coal used are indicated in the tables. The results of these tests amply justify the conclusion that this type of furnace may be depended upon to operate even under adverse conditions without objectionable smoke, for out of a total of 32 tests in only six cases could any smoke be seen coming from the stack, and in three of these six, smoke did not exceed No. 1 on the smoke chart. Where the most smoke was made, it was only Nos. 1½ and 2½, and here it will be observed that the draft had been suddenly reduced in the breeching, amounting to the condition of closing the damper with a brisk fire. The results of these experiments are given in Tables 1, 2, 3 and 4, and they certainly demonstrate the possibilities of smokeless combustion of some typical Illinois coals.

It is not within the scope of this paper to enter into any lengthy discussion of the results as shown by these tables. It should, however, be stated that this setting has been operated not only without smoke, but also with economy, as may be seen by inspection of Table 5.

SMOKE PREVENTION WITH THE HORIZONTAL FIRE TUBE BOILER

The horizontal fire tube boiler is still much in use in the smaller units of from 50 to 150 horse-power. It was brought into prominence in the early days of American steam boiler practice as the natural successor of the plain cylinder and flue boilers, all of which were externally fired. It soon became the standard type of boiler throughout manufacturing New England where in many places it still retains its position on account of its cheapness and its economical operation with all grades of anthracite and many grades of bituminous coals, especially those containing a high fixed carbon content.

With the coals just mentioned the combustion takes place mostly on the grate or at a short distance above it. Many plants have been installed with this type of boiler, in which the grate has been placed not more than 14 to 16 inches beneath the boiler. These plants have burned anthracite coal successfully. With the introduction of the West Virginia bituminous coals containing small amounts of volatile combustible matter the grates were lowered under this type of boiler to 24 and 30 inches with good effect. Still, with either coal, much the greater part of the heat was generated on or near the grate and the heat made available for transmission was largely radiant heat. The plates directly over the fire itself transmitted a correspondingly large part of the heat of the coal to the water in the boiler. The satisfactory performance of the fire tube boiler with eastern coals together with its availability made it naturally the boiler to be adopted by manufacturers moving westward with the center of population. It is easily seen, however, that with coals carrying 30 to 40 per cent of volatile combustible matter and burned at rates which produce flame lengths of from 5 to 20 feet, this type of boiler as usually set is by no means adapted for the smokeless consumption of this kind of fuel. There is, in fact, no better method of producing dense black smoke with bituminous coal than to install a horizontal fire tube boiler with the usual furnace, and hand fire such a plant with run-of-mine coal. In such an outfit all the fundamental principles laid down elsewhere in this paper are disregarded. The method of introducing the coal directly into the hot furnace, in fine dust and large lumps, prevents slow or uniform distillation of the gases; the air supply through open doors, through holes in the fire, or through a fuel bed of varying thickness, is neither correct in quantity nor is much of it properly heated; the mingling products of combustion come in contact with the cool surface of the plates of the boiler, reducing the temperature of the gases below the ignition temperature before combustion is completed.

Having in view these defects of the usual plan of operating the fire tube boiler with bituminous coal, many ways suggest themselves by which these faults may be corrected. It is possible to burn bituminous coal without smoke with fire tube boilers, but the furnace requires special treatment and such settings are not common. The plans usually proposed are either low-set stokers or extended Dutch oven furnaces. When

TABLE V

Results of Evaporative Tests with Illinois Coals on a Chain Grate Stoker

Experiment Station Boiler with Tile Roof Furnace. Same Setting as Those Used for Special Smoke Tests in Tables 1 to 4

TRIAL NUMBER	47	50	91	96	107	127	131	134
1. Duration of Trial	8.32	8.32	8.30	8.25	8.10	7.02	8.15	7.37
2. Size and Condition of Coal (1)	$\frac{3}{4}-\frac{1}{4}$(w)	$\frac{3}{4}-\frac{1}{4}$(w)	$1\frac{1}{2}-0$(2)	($1\frac{3}{4}-1$)	$1-\frac{3}{4}$(w)	$\frac{3}{8}-0$ (w)	$\frac{7}{8}-\frac{3}{8}$(w)	$\frac{7}{8}-\frac{3}{8}$ (w)
3. Per cent Moisture in Coal as fired	10.72	11.23	11.88	7.14	9.40	21.25	19.83	19.29
4. Per cent Ash in Coal as Fired	7.31	7.64	16.89	8.42	8.21	12.58	7.68	7.19
5. Per cent Carbon in Ash Free, Dry Coal	60.41	60.41	53.95	60.41	62.43	55.94	57.39	56.35
6. Per cent of Volatile Matter in Moisture and Ash Free Coal	39.59	39.59	46.05	39.59	37.57	44.06	42.61	43.65
7. B.t.u. per Pound Coal as Fired	11898	11740	10036	12305	11922	9350	10274	10391
8. Thickness of Fuel Bed at Grate, inches	6	4	6	5	6	5	5	5
9. Draft Pressure in Furnace, in. of water	0.127	0.085	0.258	0.112	0.120	0.387	0.117	0.161
10. Per cent CO_2 in Flue Gases (3)	12.60	12.28	7.00	9.52	10.99	7.10	11.46	11.38
11. Excess Air Used, per cent	43.54	47.16	150.1	83.4	56.4	143.8	57.4	57.6
12. Temperature of Escaping Flue Gases °F	599.0	612.0	613.4	606.0	599.0	624.0	574.0	665.0
13. Dry Coal per sq. ft. Grate Surface, per hour	22.48	22.35	26.41	22.10	20.49	27.62	20.60	27.55
14. Carbon in Ash and Refuse, per cent of Dry Coal	4.00	3.95	2.23	2.23	1.56	5.46	1.75	1.89
15. Steam Pressure Gage	150.0	150.0	146.9	150.4	147.5	149.5	149.4	148.3

TRIAL NUMBER	47	50	91	96	107	127	131	134
16. Per cent of Builders' Rated Horse-power Developed	109.1	109.3	103.1	101.8	99.9	99.5	101.4	133.8
17. Equivalent Evaporation from and at 212° F. per lb. Coal as Fired	8.24	8.23	6.52	8.12	8.37	5.38	7.49	7.44
18. Equivalent Evaporation from and at 212° F. per lb. Moisture and Ash Free Coal	10.51	10.60	9.42	9.86	10.34	8.70	10.53	10.33
19. Efficiency of Boiler	69.93	70.75	64.60	65.32	69.00	60.18	71.76	70.61
20. Efficiency of Boiler including Grate	66.89	67.70	62.75	63.60	67.82	56.26	70.39	69.16

(1) Item 3— Size is given in inches. (w) refers to washed coal.

(2) Sixty per cent of this coal was below ¼ inch.

(3) The flue gases were free from carbon monoxide and smoke.

Another series of evaporative tests has recently been made on this boiler both with the tile roof furnace shown in Fig. 7 and with other forms of roof tiles. The economy varies somewhat and the results are embodied in a bulletin about to be published.

hand-firing is adopted the wing wall furnace or other form of mixing baffles or piers is of great assistance. With any of these devices careful firing is very necessary for satisfactory results. The twin brick arch furnace which keeps the gases away from the boiler plates altogether is an effective smoke preventive. Careful firing with low rates of combustion (12 to 16 lb.) per square foot of grate, assisted by automatically controlled air supply will often enable these settings to be run so as to escape the fines of city smoke inspectors, but they can hardly be compared as to smokelessness with such settings as are illustrated in this paper.

The Illinois Coal Operators Association in their pamphlet, "The Use of Illinois and Indiana Coal Without Smoke" give some very helpful suggestions as to hand-firing, all of which are applicable to boilers of this type.

RULES FOR FIREMEN USING ILLINOIS AND INDIANA COAL IN HAND FIRED FURNACES

1. Break all lumps and do not throw any in furnace larger than one's fist. The reason for this is, that large lumps do not ignite promptly, and their presence also causes holes to form in the fire, which allow the passage of too much air.

2. Keep the ash pits bright at all times. If they become dark it is evidence that the fire is getting dirty and needs cleaning, which if not done will cause imperfect combustion and smoke. If the furnace is equipped with a shaking grate, it should be operated often enough to prevent an accumulation of ashes in the fire. Do not allow ashes to collect in the ash pits, as they not only shut off the air supply, but may cause the grate to be burned.

3. In firing, do not land the coal all in one heap, but spread it over as wide a space as possible as it leaves the shovel. A little practice will enable one to catch the proper motion to give the shovel to make the coal spread properly.

4. Place the fresh coal from the bridge wall forward to the dead plate, and do not add more than 3 or 4 shovels at a charge. If this amount makes smoke, it should be reduced till smoke ceases, which means, of course, that firing be at more frequent intervals than formerly to keep up steam. This rule applied

in cases where the boiler is worked at a large capacity. In such instances, however, where a small capacity only is required, firing by the coking method is the best, wherein the fresh coal is placed at the front of the fire and pushed back and leveled when it has become coked.

5. Fire one side of the furnace at a time, so that the other side containing a bright fire will ignite the volatile gases from the fresh charge.

6. Do not allow the fire to burn down dull before charging. If this is done, it will not only result in a smoky chimney, but an irregular steam pressure.

7. Do not allow holes to form in the fire. Should one form, fill it by leveling and not by a scoop full of coal. Keep the fire even and level at all times. As far as possible, level the fire after the coal has become coked.

8. Carry as thick a fire as the draft will allow, but in deciding on the proper thickness, judgment must be exercised. If the draft is poor, a thin fire will be in order, but if strong, a thicker fire should be carried.

9. Regulate the draft by the bottom or ash pit doors and not by the stack dampers, because when the stack damper is used it tends to produce a smoky chimney, as it reduces the draft, while the closing of the ash pit door diminishes the capacity to burn coal. If strict attention is given to firing, and according to demands for steam, there will be no occasion to have recourse to dampers, except when there is a sudden interruption in the amount of steam being used.

10. A good general rule is to fire little and often, according to steam demands, rather than heavy and seldom. The former means economy in fuel and a clean chimney, while the latter signifies extravagance in fuel and a smoky chimney.

The University of Illinois has recently installed a furnace of the Dutch oven type with a single firebrick arch under a horizontal return tubular boiler used for heating purposes. This has given very good results. The Department of Smoke Inspection of Chicago has developed a similar setting which is being used with good success. Both of these furnaces are adapted to hand-firing. In small mechanically operated plants, stokers of the Underfeed type have given excellent satisfaction.

The Engineering Experiment Station of the University of

Illinois during the past year has been conducting a number of further tests on fuels the results of which are soon to be published. Experiments have been conducted on power plant and house heating boilers and on hot-air furnaces. The smoke problem for large installations has been practically solved and it is hoped that future investigations will make economical and smokeless combustion possible in the smaller power plants and residence furnaces.

DISCUSSION

Prof. K. G. Smith: The paper published in the advance copy of the proceedings under the authorship of Professor Breckenridge is largely compiled from Bulletin No. 15 of the Engineering Experiment Station of the University of Illinois. I am not myself a specialist in the line of smoke prevention though I have made a considerable smoke in the course of my life and prevented some. It would be useless for me to read the paper as it is printed and consequently I shall endeavor to bring out the most important points so far as I can.

Before beginning the discussion of a subject it is always well to lay down definitely and clearly understand the fundamental principles on which an intelligent discussion must depend. The subject before us is Smoke and Smoke Prevention and the fundamental principles underlying it are the principles of combustion.

Combustion is usually defined as rapid chemical combination with the evolution of light and heat. Many substances will unite in this manner which we are not accustomed to use either for heating or lighting owing to inconvenience or expense in obtaining and handling them. For instance iron and sulphur will unite chemically evolving both light and heat. We do not, however, use iron and sulphur for heating our houses or making steam in our boilers for obvious reasons. The two substances which we most commonly use for developing heat are carbon and oxygen, the carbon being found in the coal or wood and the oxygen in the air. Two other elements also occur in coal which unite chemically with the oxygen producing heat, viz: sulphur and hydrogen; the hydrogen may occur as simple hydrogen or as a compound of carbon and hydrogen forming a combustible gas. It is with the combustion of these elements as found in coal that our discussion deals.

Every chemical combination, and combustion is a form of chemical combination, as we have said, takes place in accordance with certain fixed laws, the most important of which may be stated as follows:

(1) Whenever combustion takes place a certain fixed amount of one substance always unites with a certain fixed amount or fixed amounts of another substance.

(2) A certain temperature, called the ignition temperature must be reached and maintained before combustion will take place.

(3) The combustion of one pound of a certain element with a given element is always accompanied by the evolution of a definite quantity of heat measured in heat units.

Applying these laws to the combustion of coal we find that to burn completely a pound of carbon a fixed weight of oxygen is required, to burn a pound of hydrogen a fixed weight of oxygen is required and to burn a pound of sulphur a fixed weight of oxygen is required. This fixed weight is for a pound of carbon $2\frac{2}{3}$ pounds of oxygen, for a pound of hydrogen eight pounds of oxygen, for a pound of sulphur one pound of oxygen. You notice that I said for the complete combustion of a pound of carbon $2\frac{2}{3}$ pounds of oxygen are required. A pound of carbon will unite with just half as much oxygen, that is $1\frac{1}{3}$ pounds if there is an insufficient supply and in so doing evolves only about one third as much heat as when completely burned.

The amount of heat actually developed by the combustion of one pound of these elements with oxygen is for carbon completely burned 14,500 B.t.u., carbon burned with $1\frac{1}{3}$ pounds oxygen 4400 B.t.u. for a pound of hydrogen burned with eight pounds oyxgen 62,000 B.t.u. and for one pound sulphur burned with eight pounds oxygen 4000 B.t.u.

Fortunately for us our atmosphere is not pure oxygen, being a mixture of oxygen and the inert gas nitrogen in the proportion of about $3\frac{1}{4}$ pounds of nitrogen to one pound of oxygen. Consequently to furnish one pound of oxygen for combustion $4\frac{1}{4}$ pounds of air must be supplied and the amount of air required to burn the substances, carbon, hydrogen and sulphur, is $4\frac{1}{4}$ times the amount of oxygen required or about twelve pounds of air per pound of carbon, thirty-four pounds of air per pound of hydrogen and 4¼ pounds of air per pound of sulphur.

The fact that twelve pounds of air are required to burn a pound of carbon gives rise to the statement that twelve pounds of air are theoretically required per pound of coal. Practically from 50 to 100 per cent more air is necessary for two reasons. (1) Not all of the air entering a furnace has a chance to unite with the carbon and (2) there are other substances in coal which require more oxygen per pound to burn them than the carbon. An excess of 50 to 100 per cent would mean from eighteen to twenty-four pounds of air per pound of coal or, as atmospheric air occupies at ordinary temperatures about thirteen cubic feet to the pound approximately 225 to 300 cubic feet of air per pound of coal.

Now that we have stated the laws of combustion let us briefly illustrate them and note their application to the problem of smoke prevention, for smoke prevention means simply perfect combustion.

Mr. W. C. Lounsbury: Mention was made of mixing steam with a jet of air in burning the coal. I want to ask if it is practical to let in an air-jet instead of steam? Somebody invented a furnace in which air is admitted automatically at the furnace door, which, mixing with the flue gas over the fire passes down behind, through latticed firebrick, and then to the chimney. He does get remarkable results in the elimination of the smoke. Of course we know it is bad practice to let air in through the door, but wouldn't it be possible to get good results from doing this, if the air is warm and mixes thoroughly with the hot flue gas?

Prof. K. G. Smith: I can only answer that by telling you some things that have come under my observation. I have seen a plant which was smoking badly in which the smoke was cut down by opening the fire doors somewhat. There is another thing which also might perhaps indicate that there would not be so much loss as you would think: Professor Breckenridge told me this. He was present at one time and saw it happen. A pyrometer was put in to take the temperature of the flue gases, and it was found that when the door of the furnace was opened enough to admit a small amount of air, that instead of the pyrometer showing a lowered temperature of the flue gases, it showed a higher temperature; it showed that the admission of cold air was not cooling off the flue gases, but heating them up. The reason was that the regular draft was not strong enough to supply sufficient air for combustion.

Mr. W. C. Lounsbury: This engineer does get better results by letting cold air in. He has peep holes, and you can see that he gets better combustion.

Prof. K. G. Smith: If I am not mistaken there are some devices on the market which admit heated air. It is no use to put in any more air than necessary for complete combustion.

Mr. W. C. Lounsbury. Wouldn t it be a good thing to try and throw in more air over the coal?

Prof. K. G. Smith: Not knowing anything more about the particular plant than I do now, I would simply say offhand that I think it would be simply the same thing as opening the door a little bit to let in more air.

President French: What is the effect of the mixing piers staggered in the combustion chamber on the draft, do hey decrease it to a slight extent?

Prof. K. G. Smith: Before mixing pier devices are installed the question as to whether there is sufficient draft should be carefully considered, for there must be enough draft to take the gases through. You saw some slides in which there were several passes of the gases over the boiler tubes and in other slides I showed a greater number of passes of the gases over the tubes. A gentleman in Chicago, a pretty good engineer in that line, told me it was not safe to use such settings as that unless there was one and one-half inch stack draft.

President French: Even with a one hundred and forty foot stack we have had some difficulty in getting the best kind of results through economizers. on account of the stack not pulling properly. or not getting suitable feed water temperature through the economizer; and we have been obliged to by-pass the economizer to a partial extent in order to get draft enough to burn our coal well.

Prof. K. G. Smith; In the plant with the mixing piers to which I referred, there was ¾ inch stack draft and the boilers were not overloaded. The piers did cut down the available draft through the fire though I don't know how much. Not as much coal could be burned as before, but sufficient to carry the load.

Mr. E. M. Nichols: I understood from one view shown that the device consisted of a steam jet blowing over the fire to assist in combustion; am I right in that?

Prof. K. G. Smith: Yes, sir; I believe it was called by the inventor a steam dissociater.

Mr. E. M. Nichols: I presume if anybody would go to the Patent Office they would find on record at least a thousand devices of that sort. The whole matter depends upon a mixture of the carbon in the air with the volatile carbon thrown off as CO. If you mix it CO enough you will get CO_2; but it doesn't make any difference how you do it as long as you get them mixed in the presence of sufficient heat. Without that you cannot get complete combustion.

Mr. E. E. Davis: At one time I saw a furnace run that had a jet of water in the ash pit. I was told that as the cinders fell in the water it created oxygen and made the coal burn more easily and with a better degree of heat; is that right?

Prof. K. G. Smith: I do not think I believe that. There is a reason for putting a little jet of steam or getting some steam underneath the grate bars, because if your coal has sulphur in it, it will help to prevent clinkering.

Mr. E. E. Davis: That is my idea. I think the less clinkers the better the fire.

PURCHASE OF COAL AND OIL BY THE CLEVELAND WATER DEPARTMENT

E. W. BEMIS AND C. F. SCHULZ

I COAL

The Water Department of Cleveland pumps an average of about 52,000,000 gallons a day against a dynamic head of about 200 feet and, at another station, re-pumps about 10 per cent of this against, approximately, the same head. For this purpose from 28,000 to 29,000 tons of bituminous slack from the Pittsburgh district or from Ohio are yearly used. By a series of steps we have at last reached the method of buying this coal that will be described herewith. The underlying principle is the payment for the coal according to calorimetric tests of the heat value of each car as compared with the heating value of the sample coal submitted by the bidder before entering into contract. In an indirect way, however, attention is also paid to the amount of ash and other refuse. Perhaps the matter will be most clearly understood by an account of our last contract.

On October 31, 1908, the Rail and River Coal Company was given a year's contract at $1.55 per short ton. Their sample car when used on an eight-hour run under some of our boilers was found to give better results per dollar's worth of coal than that of the other bidders. This sample car contained 13,300 B.t.u., or British thermal units, per pound. The contract provided that every car should be tested by the Department's own examiner. Whenever any car of coal was found to have less than 12,000 B.t.u., it was to be put in a class by itself and a reduction made in the price paid for such coal equal to 3 cents per ton for each 100 B.t.u. that the coal in that car fell below the standard of 13,300.

For example, if the coal was 11,000 B.t.u. in some cars, then the price is to be found by deducting 23 times 3 cents or 69 cents from the price bid of $1.55. All the rest of the coal each month is averaged with respect to its heat units and a reduction of 1.5 cents per ton is made for every hundred B.t.u. below 13,300, and a similar premium is added for every hundred average heat units above 13,300.

Under this contract, six estimates had been made out and paid at the time of the preparation of this paper in May. The following table gives the result:

Present Contract Prices

EST. NO.	FOR THE MONTH	TONS	AVERAGE B.T.U.	PRICE	AMOUNT
1	November '08	1154.80	13,466	1.58	$1,824 58
2	December '08	1583.18	13,355	1.565	2,480.21
3	January '09	2129.77	13,218	1.535	3,269.47
3	January '09	30.25	10,776	.77	23.29
3	January '09	32.09	11,384	.95	31.25
4	February '09	2028.43	13,475	1.58	3,206.06
5	March '09	1606.14	13,326	1.565	2,515.58
6	April '09	1640.54	13,466	1.58	2,593.33
	Total	10205.20			$15,943.77

It will be observed that in January there were two cars of such low heat units that the price per ton was only 77 cents for the 30 tons having an average of only 10,776 B.t.u., and 95 cents for the other car of 32 tons having an average of 11,384 B.t.u. It will also be noticed that the average price that month, January, 1909, for the rest of the coal, about 70 cars, was $1.535. Every other month the coal has averaged better than the standard car and the average price has, therefore, been from 1. 5 cents to 3 cents a ton above the bid. The average price on the entire coal used during the first six months of the present contract has been $1.562 or 1.2 cents above the contract price. Another company having the contract for coal in the previous two years at $1.79 on Pittsburgh coal with 13,624 B.t.u. in the sample car secured an average price in 1906–07 of $1.74 and in 1908 of $1.734.

The difficult question has been the determination of how much reduction should be made in the allowance for coal for every hundred reduction in heat units. If the question of ash and refuse did not affect the matter, a reduction of about 1⅓ cents per ton would be sufficient instead of 1½ cents actually incorporated in the contract for moderate reduction or increase of heat units and 3 cents for large reductions. The 3 cents is in the nature of a penalty. The scientific reduction per heat unit has been worked out by the chief engineer of the Water Department, Mr. C. F. Schulz. He starts with the assumption that a pound of the standard coal[1] when dry contains 13,600 B.t.u. and costs $1.79 per ton, while the cost of removing the ashes and refuse is 25 cents per ton of such ashes, while the cost of unloading the coal from the cars into bins underneath the same by merely dumping the hopper cars is so slight as to be neglected. It was further assumed that in coal of standard quality there is 10 per cent of ashes and 5 per cent of unburnt combustible or refuse.

In other words, there is 90 per cent of combustible in coal of standard quality, although only 85 per cent is consumed. The unburnt combustible is 5 per cent of the coal or 5.55 per cent of the combustible part of the coal; that is, of the 90 per cent capable of use. If a pound of coal contains only 90 per cent of combustible, then a pound of combustible contains $1\frac{1}{9}$ as many heat units as a pound of coal, $1\frac{1}{9}$ of 13,600 B.t.u. is 15,111 B.t.u. The refuse in all cases is assumed to remain 5.55 per cent of the combustible.

The full analysis of the subject, as prepared by Mr. Schulz, and a summary of the more significant paragraphs of our specifications are appended.

The quality of coal obtained under these contracts has been more uniform and satisfactory than previously. We may not have the data to prove the assertion, but we fully believe that this method of purchase has resulted in a considerable saving to the Department.

SUMMARY OF COAL SPECIFICATIONS

The specifications of last September had the usual provisions regarding time and place of delivery, approximate amount of coal needed, the certified check to accompany the bid, the bond for the contract, etc. The bidders were required to state the name and location of the mines and the thickness of the veins from which the coal was to be furnished and the approximate amount from each mine. About 95 per cent of the coal was to be slack and all of it should be, if desired by the Superintendent of the Water Department. The coal was to be "clean, free from stone, slate and other impurities, and equal in all respects to the best products of the mines from which it was produced and to the sample furnished." It must also be "fresh mined, dry burning coal" and not coal that melts or adheres to the grates.

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[1] Such as is generally furnished to the Water Department.

Provisions for furnishing a sample car load or more for tests under boilers and otherwise, and further provisions for penalties and premiums, according to the heat units, as already described, are in these specifications. The city can accept the company's weight or may have any or all the cars, both loaded and light, weighed at its own expense on the city's track scales. No demurrage is paid on account of delays in unloading cars if caused by either the contractor or the railroad company placing more cars at any one time than can be unloaded readily, or through any other fault of contractor or company.

OIL

On August 5, 1905, the Cleveland Water Department, following the example of Buffalo and I think Minneapolis, began buying oil on the basis of a price per million gallons of water pumped, instead of so much per gallon as hitherto. The result has been that we get oil at little more than half of the price previously paid. The following table gives the cost of oil, both cylinder and engine, and of grease, or, in other words, the total cost of lubricants per million gallons of water pumped, and also the gallons of cylinder and engine oil per million gallons of water, and the average cost per gallon of oil, both before and after August 5, 1905. When oil was bought by the gallon or barrel, the Department owned the barrels, while that was not true when oil was bought by the water pumped.

Allowance is made for this in the table.

YEAR	GALLONS OF OIL PER MILLION GALLONS OF WATER	AVERAGE COST PER GALLON	COST OF OIL PER MILLION GALLONS OF WATER	COST OF GREASE PER MILLION GALLONS OF WATER	COST OF LUBRICANTS PER MILLION GALLONS OF WATER
1903	0.6336	19.68¢	12.469¢	0.321¢	12.79¢
1904	0.5880	23.80	13.994	0.962	14.96
1905*	0.5066	23.83	12.972	0.623	12.70
1905†	0.5262	11.78	6.198	0.745	6.95
1906	0.4813	12.88	6.199	0.718	6.92
1907	0.4285	14.28	6.119	0.603	6.724
1908	0.5958	9.25	5.511	0.723	6.234

* For first eight months of 1905.

† For last four months of 1905.

The result in every way has been satisfactory.

The price has been steadily falling, as indicated by the following table:

Price of Lubricants per Million Gallons of Water Pumped at our Chief Station, Kirtland Street, According to Each Contract

DATE OF CONTRACT	SUCCESSFUL BIDDER	PRICE
August 5, 1905	Buffalo Refining Company	6.95¢
October 15,1906	Standard Oil Company	6.74¢
December 3, 1907	Buffalo Refining Company	6.24¢
December 12, 1908	Standard Oil Company	6.15¢

The more interesting and significant parts of our last oil specifications are appended.

In the oil specifications, the water pumped at each station, and some of the conditions under which it is pumped, and the amount of oil used the past year are stated. The specifications also include the following items:

> Bidders are invited to visit the stations for which oil and grease are to be furnished, and inform themselves as to the quantity and quality of the lubricants best suited for the different engines or different parts thereof.
>
> Each bidder must submit a sample of each kind of lubricant he proposes to furnish, the samples to be properly labeled to denote the kind of the lubricant and for what particular service it is intended.
>
> Bidders, if required, shall submit a list stating name and location of some of the firms at present supplied by them.

Increase in Ash and Refuse Per Ton of Coal Consumed, for Each 100 B.t.u. Decrease in Heating Value

B.T.U. PER POUND OF COAL.	COMBUSTIBLE = B.T.U. PER LB. 15111	ASH = 100% − COMBUST.	REFUSE = $i. 2 \times 5.55\%$	TOTAL ASH AND REFUSE = $i. 3 + i. 4$	INCREASE IN ASH AND REFUSE OVER STANDARD COAL.	
					Total	Average per 100 B.t.u.
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
13600	90	10	5	15		
13500	89.34	10.66+	4.96	15.62	0.62+	0.62+
13400	88.68	11.32+	4.92+	16.24+	1.24	0.62+
13000	86.03	13.97	4.77+	18.74+	3.74+	0.625
12100	80.07	19.93	4.44+	24.37+	9.37+	0.625
12000	79.41	20.59	4.41	25.0	10.0	0.625
10000	66.18	33.82	3.67	37.49+	22.49+	0.625

Table Showing the Increase in Coal Required to Produce a Unit Amount of Steam, and the Corresponding Increase in Ash and Refuse, for Each 100 B.t.u. Decrease in the Heating Value of the Coal

B.T.U. PER POUND OF COAL	COAL REQUIRED = 13600 / ITEM 1	ASH AND REFUSE = ITEM 2 × ASH AND REFUSE PER TON	INCREASE IN ASH AND REFUSE			REMARKS
			Total	For each 100 B.t.u. decrease in h. value.		
	Tons	*Tons*	*Tons*	*Tons*	*Pounds*	
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	
13600	1.00	0.15				
13600	1.007407	0.1574	.0074	.0074	14.8	
13400	1.014925	0.1648	.0148	.0074	14.8	
13000	1.046154	0.1960	.0460	.0078	15.6	Average fr 13400–13000°.
12100	1.123967	0.2739	.1239	.0086+	17.2	Average fr 13000–12100.
12000	1.133333	0.2833	.1333	.0094	18.8	
10000	1.36	0.5099	.3599	.01133	22.66	Average fr 12000–10000.

Schedule of Prices per Ton of Coal to be Paid for Coal Furnished under Contract No. 7923 *Made October* 31, 1908.

STANDARD COAL — 13,300 B.T.U.....CONTRACT PRICE $1.55 PER TON

Average B.t.u. per month.	*Price per ton.*
13,601–13,700	$1.61
13,501–13,600	1.595
13,401–13,500	1.58
13,301–13,400	1.565
13,300–	1.55
13,200–13,299	1.535
13,100–13,199	1.52
13,000–13,099	1.505
12,900–12,999	1.49
12,801–12,899	1.475
12,701–12,799	1.46
12,601–12,699	1.445
12,501–12,599	1.43
12,401–12,499	1.415
12,301–12,399	1.40
12,201–12,299	1.385
12,101–12,199	1.37
12,000–12,099	1.355
11,900–11,999	1.13
11,800–11,899	1.10
11,700–11,799	1.07
11,600–11,699	1.04
11,500–11,599	1.01
11,400–11,499	.98
11,300–11,399	.95
11,200–11,299	.94
11,100–11,199	.89
11,000–11,099	.86
10,900–10,999	.83
10,800–10,899	.80
10,700–10,799	.77
10,600–10,699	.74
10,500–10,599	.71
10,400–10,499	.68
10,300–10,399	.65
10,200–10,299	.62

All oil and grease shall be of standard quality, suitable for the purpose for which it is intended, and to be approved by the Superintendent, who shall have the power to reject any oil or grease which in his opinion does not properly do the work for which it is intended.

All the lubricants furnished under any contract that may be entered into shall conform strictly to the samples submitted, and no change shall be made in the quality of the lubricants except as may be ordered by the Superintendent, or as may be mutually agreed upon between the Contractor and the Superintendent. All such orders or agreements to be made in writing and to be within the price bid.

Tests and analyses may be made of the samples submitted and also of the lubricants furnished under contract in order to determine the quality of the same.

CONCLUSION

While further requirements in the purchase of coal and oil may be necessary in some plants, and may in fact be found desirable at some later time in Cleveland, we are very well satisfied with the result obtained by the coal and oil specifications of the last three or four years. We can heartily commend to other Water Departments the methods above described for the purchase of these important commodities.

DISCUSSION

Mr. E. W. Bemis: This paper is a good deal of a composite. Mr. Schulz and myself prepared the paper together. While I had much to do perhaps with initiating the methods which I am going to refer to, Mr. Schulz carried out the details and is here to join in the discussion.

The boiler house is our greatest boast in connection with our machinery. Professor Benjamin, formerly one of the leading men in Ohio in engineering lines, Professor in the Case School, and now at the head of the Rose Polytechnic at Terre Haute, Indiana, has pronounced it the most economical boiler house in the state of Ohio either in private or public work; and that means a good deal when you consider that there are so many plants of the American Steel and Wire Company, and of street railway and lighting companies and other large corporations. The same remark was made to me by Professor Magruder of the University of Ohio at Columbus, after he had taken his class to visit some of the most important stations in the state.

We feared there would be constant friction between the engineers of our stations in operation at present and the contractor, with regard to whether oil was being used wastefully or not, or as to whether or not the oil was of a satisfactory quality. To our surprise we have had no trouble of any kind, although a very sharp competition existed each year; and although two companies had the contract alternately, they bid against each other very sharply.

Mr. S. Bent Russell: I would ask Mr. Bemis to explain how bids for coal are compared. By what method of testing do they determine which is the best coal to buy? Is the weight of water evaporated for a dollar's worth of coal the only factor considered? If not, what other factors are considered and in what way? It is understood, of course, that the coal must comply with the specifications.

Prof. E. W. Bemis: I will answer that by giving one of our tests as shown in one of our annual reports. Better wait until after the discussion, and I will look it up.

President French: Gentlemen, there are several papers here, all of which it seems would mix well with each other along this particular line; so I think it would be a wise economy of time for us to listen to these papers before a general discussion is entered upon. I will therefore ask that the next paper, upon The Purchase of Coal upon Heat Value Contract, by Mr. Edward H. Taylor, be now presented.

Mr. Edward H. Taylor: It will be unnecessary for me to consume the time of the Association in reading my paper in detail, as it is printed in the advance copy. However I wish to emphasize a few of the points.

The first point I wish to call attention to is, that a great many of us have found that it was advisable and feasible to purchase coal upon heat value units, that is by making B.t.u. contracts. We first started this method of purchasing about eight years ago. The first year we purchased about 20,000 tons upon that basis. It ran on for three years and the tonnage increased to 40,000 tons. As we had a great many inquiries from private concerns that wanted us to look after their coal, business increased and at the present time we are purchasing a million and a half tons, and the proposition has grown into such proportions that the plan has been adopted all over the country.

THE PURCHASE OF COAL UPON A HEAT VALUE CONTRACT

EDWARD H. TAYLOR

The purchase of coal upon heat value specifications has developed to such proportions in this country that consumers and producers, who, a few years ago, ridiculed the idea are now awakening to the fact that the subject must be given careful consideration.

I am unable to state definitely when this method of purchasing fuel was first used in this country. Many years ago specifications were drawn upon the basis of evaporative tests, but the determining of the value of coal deliveries by chemical analysis was, to my knowledge, first used in Chicago by Mr. Edwin H. Cheney, then vice-president and general manager of the Illinois Maintenance Company.

In the year 1902 he first made use of a heat value contract in the purchase of 20,000 tons of bituminous coal for consumption in the buildings that the Illinois Maintenance Company were operating. The contract used at that time, with several modifications, is the one which I am using at the present time for the purchase of over a million tons of coal. This same form of contract has been adopted by many large coal consumers.

Before proceeding further with the discussion of contract forms, it might be well to look into the causes which necessitate the purchase of coal upon specifications, it being possible that some members of this association still doubt the necessity or advisability of so doing.

I think that every one will admit that the quality of coal delivered upon any contract will fluctuate. Let us then investigate the causes which bring about these fluctuations and see if they are within the province of the coal producer to control.

First, we will examine the calorific value. Several thousand calorimeter tests made under my direction show that the calorific value per pound of true combustible is practically constant in any given mine. For three consecutive years I have made determinations on coal from certain mines and find that, at the same per cent of ash, I obtained practically the same B.t.u. each year; also that the B.t.u. per pound of dry coal increases or decreases a certain fixed amount, according to the kind of coal, for each per cent of dry ash, the factor of change ranging from 150 B.t.u. to 200 B.t.u. How these comparisons were made and this data attained, I will explain later.

The dry ash varies continually. In some mines the variation is much greater than in others. In the Dering mine, No. 44, Vermillion County, Illinois, the dry ash in the mine run covering a year's delivery varied from 9.8 per cent to 16.7 per cent.

This variation was not attributable in any way to the sample taking, as the same was performed with great care and the samples analyzed were made up of composite samples representing at least ten cars, a sample of 100 lb. having been taken by the standard method from each car.

The cause of this variation was due to the peculiarity of the roof of the mine, which air slacks badly. If the coal was mined daily from a particular room the ash was much lower than if mined on alternate days, as the roof would not come down until after the coal had been loaded and the floor cleaned up. At times when vigorous complaints mere made, inspectors were placed upon the cars and the coal prepared so that the ash would not run over 12 per cent.

The product from almost any mine will vary with the care used in mining, some seams having slate bands or draw slate at the top of the coal, which can be excluded by careful preparation. Therefore, we find that the quantity of ash can be regulated to some extent by the producer. The manner in which I satisfy myself if the producer is using proper care, is to take a face sample of the seam and determine the ash upon the same. From this I check future deliveries. If the ash exceeds the ash determined in the face sample it is evident that the producer is allowing the roof and bottom to be loaded with the coal.

Of course, it is impossible to keep the coal absolutely free from all extraneous impurities.

The moisture in coal as delivered varies also with the climatic conditions. This is not within the control of the operator. At the same time, if the coal is purchased on destination weights, it operates to his benefit and should be considered; while if the coal is purchased on mine weights, it should be a constant.

Variation in sulphur from a given mine depends upon the form in which the sulphur is present in the seam. If it be organic sulphur it is generally constant. If it is in the form of pyrites and found in the seam in large balls, commonly called "nigger heads," it can be removed so that the quantity of sulphur in a high sulphur mine can be somewhat controlled by the producer.

The volatile matter and fixed carbon vary in dry coal from a given mine but slightly and they are entirely beyond the power of the producer to control.

We have now covered the various causes of fluctuation due to mining conditions and find that same can be controlled by the producer.

However, we have not touched upon all causes of fluctuation. The coal contractor is pirectly responsible many times for the fluctuation on account of substituting coal other than that contracted for, coal of an inferior quality often being secured at a lower freight rate.

For many years it was believed that by having the coal contractor furnish bills of lading with all coal delivered, it would prevent the substitution of one coal for another. This, however, does not work out, as in many fields a large number of mines will bill from one shipping point, these mines varying in quality most decidedly. Change in the size delivered also causes fluctuations, this being entirely the fault of the seller.

All of the above fluctuations in quality of coal delivered are liable to cause loss to the consumer. Therefore, in order to minimize this loss, it is necessary to purchase coal upon some form of contract which will reimburse the consumer for such loss as he may sustain when the loss is caused by the delinquency of the contractor.

It is by no means a simple matter to draw standard specifications which will be fair and equitable to all concerned.

The first step necessary in my mind is to adopt a universal basic principle for all heat value contracts. The basic principle of any heat value contract, in point of law, must be that any deduction made for the delivery of inferior coal shall only off-set the loss actually sustained and shall not work as a benefit to the consumer.

In other words, if coal of an inferior grade is delivered to a certain plant on a specific contract for a period of thirty days and the same increases the cost of making steam in that plant $100 for such period, the consumer would have a legitimate claim against the coal contractor for the $100 and could undoubtedly collect the same.

Therefore, a contract should be so drawn that the deductions made under its terms would only collect the amount of loss sustained and not deduct a larger sum.

If the consumer keeps his plant in proper operating condition all the time, his cost of fuel to evaporate one thousand pounds of water in his boiler will remain practically constant providing the same coal is delivered. The fuel that will evaporate one thousand pounds of water at the least cost is the fuel best suited for his plant, providing said coal will produce the horse-power necessary to be obtained in his regular operation.

The consumer having determined the fuel best suited for his use, cost and capacity considered, should then purchase the same upon a contract drawn upon the heat value basis, the terms of settlement being so arranged that if the coal delivered on this contract varies in quality from the contract grade, the contract should provide for a change in price of the coal, which will make the coal equal to the contract grade regarding cost of producing one thousand pounds of steam. If the coal delivered is better than the grade contracted for, the evaporative power of the coal will increase. The price, therefore, should be increased a sufficient amount to keep the cost of evaporating one thousand pounds of water at the same figure it was when the contract was signed. If the quality of the coal delivered is below contract grade, vice versa. A contract which alters these conditions is an absurdity and would not stand the test if taken into court.

The following, Chart I, illustrates what I believe to be correct.

In order that you may have a clear understanding of the terms specification and contract as used in this paper, let me state that the two terms are synonymous.

Many writers upon this subject contemplate the drawing of specifications in such manner that they will secure the coal best suited for a particular plant. This it would be possible to do for certain classes of plants, but it would be impossible to make a universal specification.

The point which I am endeavoring to make is that we should

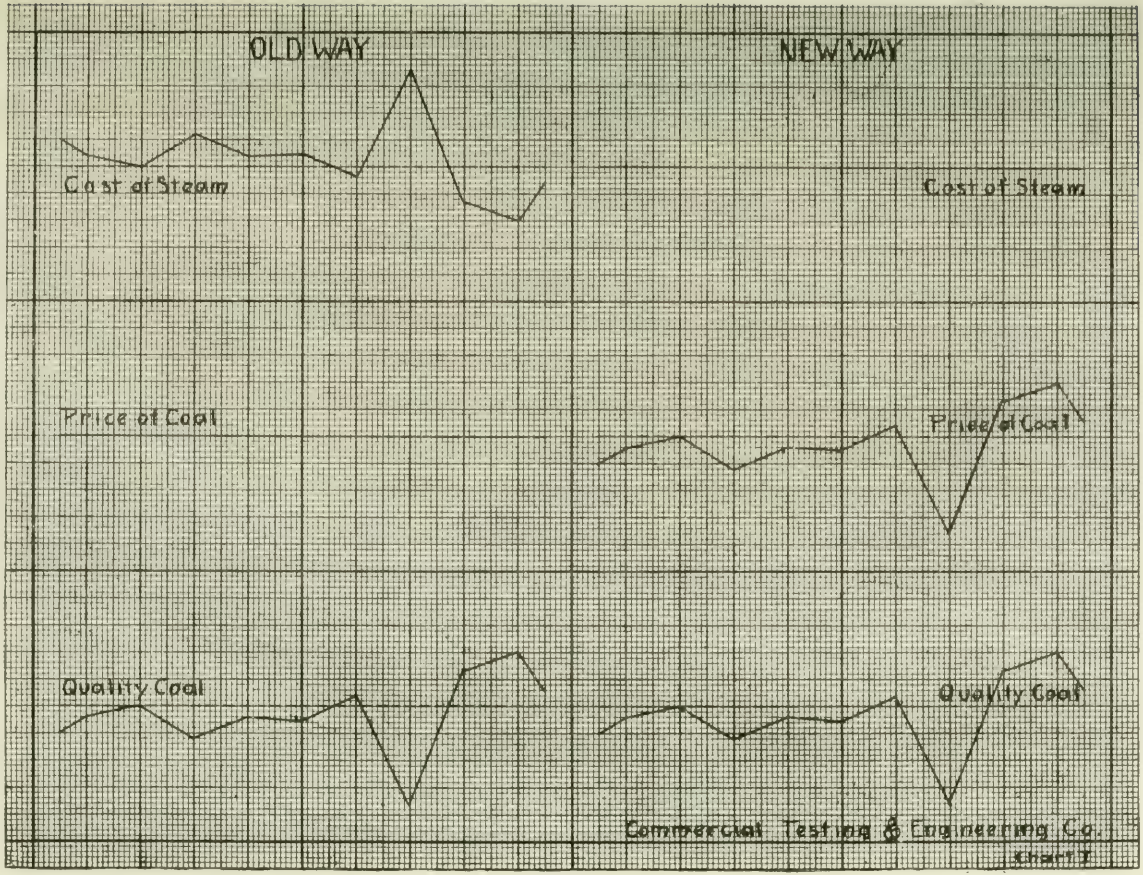

OLD WAY
NEW WAY
Cost of Steam
Cost of Steam
Price of Coal
Price of Coal
Quality Coal
Quality Coal
Commercial Testing & Engineering Co.
Chart I

CHART 1

have a universal form of contract, one that is fair and equitable. This form of contract should provide for settlement of all differences in quality in a definite manner; the producer should state just exactly what he has to sell and the terms upon which he will sell it. It is foolish for a consumer to attempt to determine by specification the kind of coal he wants delivered, as in many such cases where this attempt has been made, you will find that the coal contractor has been entirely unable to make such delivery, or that the price was prohibitive.

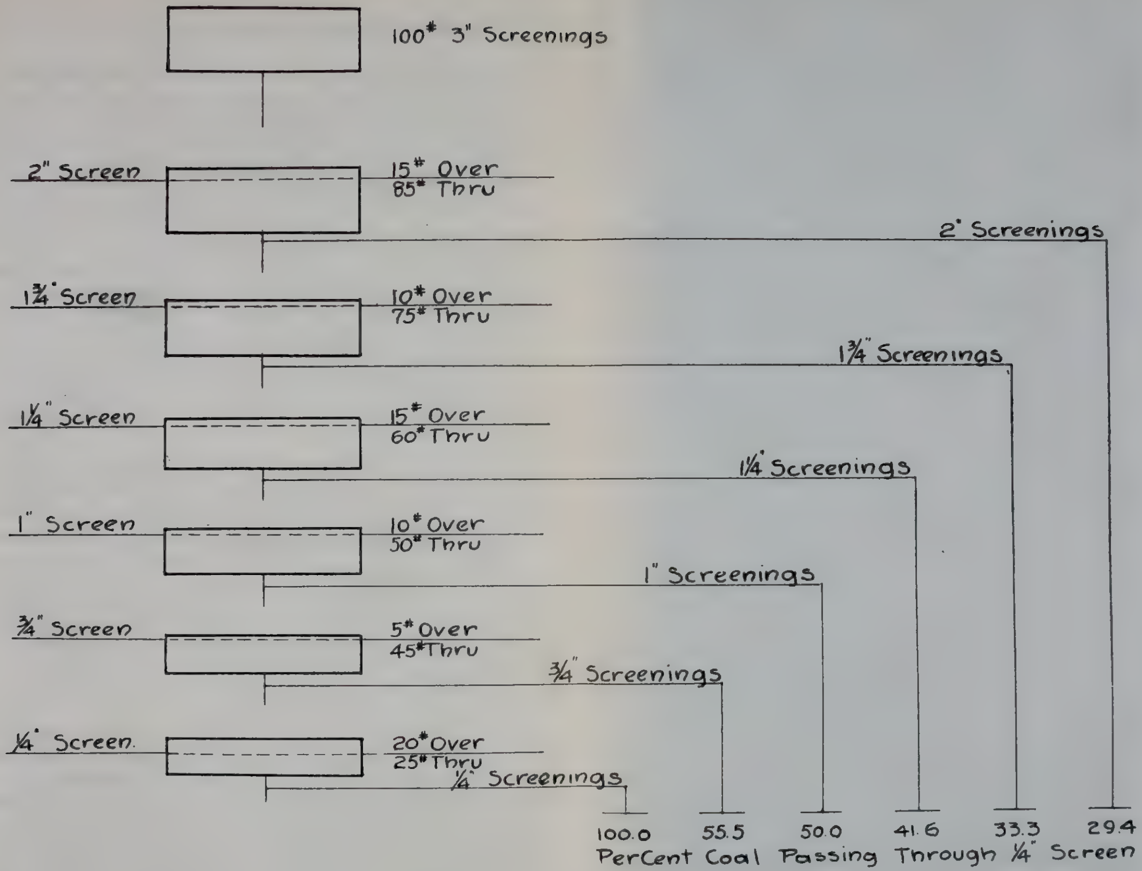
It is all right in advertising for bids to state approximately what you want, but to attempt to dictate to the coal producer what he shall produce and deliver, whether he has it or not, is only starting trouble.

With this understanding, I will now proceed to give you my idea of how a universal heat value contract should be drawn, comparing the same with other so-called heat value contracts which have been suggested.

In the first place, a contract should contain three distinct features. One, covering conditions of delivery, requirements, and such points as local conditions may necessitate being covered; another quality and price, mode of determining same; a third, size, penalty and mode of determining same. This feature must conform to the basic principle which I outlined in order to be fair and equitable.

We have already noted that moisture and ash cause fluctuation in quality. Therefore, a correction in price should be made for them.

We will first take up moisture. The delivered value of all coal purchased on destination weights should be determined on the moisture in the coal as delivered and calculation made which will change the price according to the variance in the moisture from the contract guarantee. If, however, the coal is purchased upon mine weights, the moisture of the seam should be the moisture used in the contract guarantee, and should be used as a constant at all times, as the increase or decrease in moisture during transit would not make any difference to the consumer. It is true that B.t.u. per pound as delivered would be lower if water were added to the coal, but the weight of the coal would be increased by the amount of water so added, the number of B.t.u. remaining the same.



Commercial Testing & Engineer Co

Chart II

A deduction should be made from the contract price for increase of ash above contract guarantee. This deduction should be made owing to the damage the ash does to the burning efficiency of the coal. The calculation necessary to correct the price for increase or decrease in ash is a difficult one to make. The one used in the form of contract which I shall submit, closely follows the results obtained in actual plant operation and is far the best method of correction I have yet seen.

I do not believe a correction should be made for volatile matter, because the heating value of the volatile matter is covered in the calorific determination. If volatile matter containing heat is lost in shipment, the price will be altered according to decrease in B.t.u. If the volatile matter which is lost is inert, it would not effect the heat; neither will it affect the burning of the coal. The manner in which volatile matter is determined is so unsatisfactory and subject to so much criticism that it should not be allowed to enter into any calculation determining price.

Again no correction should be made for sulphur. In the first place if the sulphur is in the form of gypsum it makes no difference, except to increase the ash, a correction for which has been provided. If it is in the form of pyrites, it gives off some heat and in burning oxidizes and increases in weight three-eighths of its own weight and is corrected for in the ash. The change of one-half of 1 per cent in sulphur, I do not believe, is at all noticeable in the burning of the coal. Since this question of specifications has been under consideration I have caused a large number of observations to be made on this point and I cannot find that the change of one-half of 1 per cent of sulphur is noticeable.

A consumer when contracting for steam coal should note the sulphur the coal contains and not buy coal which contains such amount of sulphur as to be objectionable for his use. Steel companies of course are much interested in this matter and aim to buy coal that does not exceed one per cent. I am using many thousand tons of coal today in steam plants which come from Illinois seam No. 6, where the sulphur runs over 4 per cent. This coal is being consumed on hand-fired grates and mechanical stokers and in no instance do we have trouble in maintaining a satisfactory boiler and furnace efficiency.

A correction in the price should be made for increase or decrease in B.t.u. from the contract guarantee in direct proportion as the increase or decrease affects the quality of the coal delivered.

I note that some engineers have injected into their contracts clauses which penalize the coal companies for coal which produces clinker. The clinkering qualities of coal should not be considered or corrected for in the price, as the conditions under which the coal is consumed bear a very important relation to the action of the coal in burning.

At present the Louisville Lighting Company of Louisville is using Fox Ridge Coal from the Straight Creek District, Southeastern Kentucky. This coal contains less than 1 per cent sulphur and about 9 per cent dry ash. It is burned on Roney stokers. Although this coal is high grade, one of the best in Southeastern Kentucky, nevertheless, when the plant is being pushed, the ash fuses and makes a most annoying condition. The same coal on hand fired plants gives the best satisfaction. The same statement can be made regarding certain Illinois coals, particularly the No. 5 seam in the Springfield district. Screenings from this district are very high in ash and sulphur, 20 per cent ash, 4½ in sulphur. On chain grates we have comparatively no trouble at all in handling this coal, while the mine run and lump from the same mine causes considerable trouble in hand-fired plants where we are compelled to force the fires.

The third feature of the contract should deal with the question of size. By this I mean that the amount of duff, or coal that will pass through a screen having a circular perforation of one-fourth inch in diameter, should be specified in coal of all sizes. The value of any coal depreciates rapidly with the increase of duff, combustion being seriously retarded. A paper presented before the Western Society of Engineers, September 5, 1906, by Mr. W. L. Abbott, describing experiments made by A. Bement, goes into this question thoroughly.

I have only attempted to correct price for variation in amount of duff over contract guarantee during the past two years, in which time I have collected a considerable amount of data upon that size of coal which is generally called screenings, nut and slack. The following, Chart II, was compiled from several hundred screen tests made upon Illinois nut and slack, coming from various mines and seams.

The product from a large percentage of mines will check closely with this chart. However, some will vary greatly. I find by determining the amount of coal passing through a screen having circular perforations one-fourth inch in diameter, that it enables me to determine with a good degree of accuracy the size of screen through which all of the coal originally passed. It is a common trick among jobbers to sell 1¾-inch screenings and deliver 1¼-inch or 1-inch in place thereof. Under my form of contract if 1¾-inch screenings are purchased it must not contain to exceed 33⅓ per cent of duff. If it contains more than that, I do not value it as 1¾-inch screenings, but place it in a lower grade. I am now making tests upon mine run coal and screenings produced through diamond bar screens, but have not as yet collected sufficient data to prepare a chart. I have some fifty tests, however, on 1¼-inch diamond bar screenings. The percentage passing through a diamond bar screen having clear spaces of 1¼ inches between the bars is 35 per cent, making it equal to a circular perforation of 1¾ inches in diameter.

The following is my idea of a universal form of contract embodying the three principal features which I have already suggested:

COMMERCIAL TESTING & ENGINEERING CO., OF CHICAGO—STANDARD COAL CONTRACT

THIS AGREEMENT, made and entered into by and between

....

of ....hereinafter called the "Consumer'

and ....

of ....hereinafter called the "Company,"

Witnesseth that,

WHEREAS, it is desired by the parties hereto to enter into a contract of purchase and sale of coal upon the heat value basis, as herein set forth

NOW, THEREFORE, in consideration of the mutual covenants and agreements herein contained, the parties hereto do hereby agree as follows:

QUANTITY

I. The Company hereby agrees to sell to the Consumer, and the Consumer hereby agrees to buy from the Company, all of the coal needed by the Consumer (except test coal as herein provided), for consumption during the term of this contract, on its premises as follows: ....

....

POINT OF DELIVERY, ETC.

The Company further agrees to furnish coal herein contracted for, of the grade and in such quantities, and delivered to the Consumer. —..............

....

at such times as ordered by the Consumer from time to time during the term of this contract, of any or all the kinds (as the Consumer shall determine hereunder) of coal described below.

KIND

Kind of coal..

SIZE

(*A*) Of size containing all of the coal that will pass through a screen having circular perforations of the following diameter in inches

(*B*) Or containing all the coal that will pass through a diamond bar screen having the following clear distance in inches between the the bars..

(*C*) And containing *not more* than the following percentage of coal by weight that will pass through a screen having circular perforations of one-quarter of an inch in diameter..

ORIGIN

Said to be mined from Geological seam number..

In the following County..

Of the following State..

ANALYSIS GUARANTEE

It being agreed that said coals shall approximate the following analyses..

Percentage of moisture in coal as delivered..

Percentage of ash in dry coal..

British thermal units per pound of dry coal..

KIND

Coal of the description and analysis above specified is hereinafter known as the contract grade of the respective kinds. If more than one kind of coal is described above, the Consumer shall notify the Company in writing, within thirty days after date hereof, which kind or kinds of coal and what proportion of each it wishes to receive. If no notice is sent as above, it is understood that the Company shall deliver only the kind of coal described by the left-hand column of data.

PRICE

II. The Consumer hereby agrees to pay the said Company during the calendar month following delivery for each ton of 2000 pounds avoirdupois of coal delivered and accepted in accordance with all the terms of this contract, a price per ton determined by taking the average of the Delivered Values obtained from the analyses of all the samples taken during the preceding month, said Delivered Value in each case being obtained as follows: Multiply the number of British thermal units delivered per pound of dry coal by the percentage of moisture delivered (expressed in decimals); subtract the product so found from the number of British thermal units delivered per pound of dry coal; multiply the remainder by 2000 and divide this product by the CONTRACT GUARANTEE, as hereinafter defined; from this quotient (expressed as dollars and cents) subtract one-half of the dry ash percentage delivered (expressed as cents).

CONTRACT GUARANTEE

The Contract Guarantee, above referred to, shall be the following respective numbers of Net British thermal units for one cent:

NET B.T.U. FOR ONE CENT

Kind of Coal.	*Contract Guarantee*	*Rate per Ton*
....	......................................Net B.t.u. for 1c	....
....	......................................Net B.t.u. for 1c	....
....	......................................Net B.t.u. for 1c	....

Said net British thermal units for one cent shall in each case be determined as follows: Multiply the number of British thermal units per pound of dry coal by the percentage of moisture (expressed in decimals); subtract the product so found from the number of British thermal units per pound of dry coal; multiply the remainder by 2000; and divide this product by the Rate per Ton (expressed as cents), plus one-half of the ash percentage (expressed as cents).

TEST COAL

III. It is provided that the Consumer may purchase for consumption at said premises, coal other than herein contracted for, for test purposes, it being understood that the total of such coal so purchased for such test purposes shall not exceed 5 per cent of the total consumption during the term of this contract.

REJECTION OF COAL

IV. It is understood that the Company may deliver hereunder, coal in which the percentage of ash is as high as 3 per cent more, and in which the percentage of moisture is as high as 5 per cent more and in which the number of British thermal units per pound dry is as low as 500 fewer than specified above for contract grade. Should any coal delivered hereunder contain more than the percentage of ash or moisture, or fewer than the number of British thermal units per pound dry allowed under this Clause, the Consumer may, at its option, either reject or accept same.

It is understood that the Company may deliver hereunder, coal in which the percentage by weight of coal which will pass through a screen having a circular mesh one-quarter of an inch in diameter is as high as 5 per cent more than specified above for contract grade.

Should any coal delivered hereunder contain more percentage by weight of coal which will pass through a screen having a circular mesh one-quarter of an inch in diameter than is allowed under this Clause, the Consumer may, at its option, either reject same or accept same, and deduct from its Delivered Value as liquidated damages, an amount equal to 1½ per cent of the Rate per Ton, above mentioned for each one per cent, so in excess of the 5 per cent allowed in this Clause.

SAMPLING

V. For the purpose of determining the quality of coal delivered hereunder, it is agreed that the Consumer shall cause, at his own expense, to be collected under the direction of the Commercial Testing and Engineering Company, of Chicago, fair samples at least once each day, of all coal delivered by wagon and from each car when deliveries are by railroad. The Company may have a representative present at the time of selection of any and all samples, and when requested by the Company in writing, such samples shall be divided into three parts, one given to the Consumer, one to the Company, and the third sealed in the presence of the representatives of both, and held by the consumer.

ANALYSIS

VI. All such original samples collected by the Consumer shall be delivered to the Commercial Testing and Engineering Company, for analysis; the results, together with the Delivered Value determined by such analysis, shall be reported promptly both to the Consumer and to the Company. If the Company requests, in writing, within five days after its receipt of such report from the Commercial Testing and Engineering Company, the third sealed part of the sample held by the Consumer shall be delivered to a Chemist of high standing in fuel analysis, to be mutually agreed upon, and analyzed at the expense of the Company. The Delivered Value determined by this analysis shall be final and binding.

SCREEN TESTS

VII. For the purpose of determining the size of coal delivered hereunder' it is agreed that the Consumer may cause Screen Tests to be made under the direction of the Commercial Testing and Engineering Company, and at his own expense. The Company shall be given notice of all such tests, and shall be given reasonable time to have a representative present, who shall be privileged to check the results of the tests.

STRIKES

VIII. It is agreed that when, as the result of an act of Providence, or of strike or strikes at the mines or on the railroad, it is impossible for the Company to deliver coal hereunder, the obligations of delivery and acceptance of coal hereunder shall cease until such strikes are over, or delivery of coal can again be made, provided the Company notifies the Consumer in writing of such probable inability to deliver coal as soon as the Company first has knowledge of such probable inability. It is further agreed that when such strikes are over, or delivery of coal can again be made, the rights and duties of the parties hereto shall be the same as before cessation of deliveries occurred.

FAILURE TO DELIVER

IX. Should the Company fail to deliver coal in accordance with the terms of this contract, the Consumer may, at its option, cancel the then unexpired portion of this contract, or the Consumer may purchase on the open market such an amount or amounts of coal as the said Company shall fail to deliver, in which events all costs and expenses occasioned by such failures, in excess of the cost hereunder of an equivalent amount of coal of corresponding grade, shall be borne and paid by said Company.

STORAGE

X. In addition to all of the coal herein above contracted for, the Company hereby agrees to sell to the Consumer, and the Consumer hereby agrees to buy from the Company, under the terms and conditions set forth in this contract,..........................tons of coal of the contract grade of the kind of coal specified under Clause I, and the Company further agrees to place (as hereinafter provided) and carry in storage at ....
....
said...tons of coal of contract grade and deliver the same to the Consumer when and as ordered from time to time, by the Consumer, after ....19..........., and prior to....................19............
The Consumer agrees to pay for such coal so stored and delivered the sum of ....cents per ton in addition to the Delivered Value of said coal, it being understood that the Delivered Value of said coal shall be determined in the same manner as previously provided in this contract, except that the contract guarantee shall be reduced 2 per cent as an allowance to the Company by the Consumer for depreciation. The Company agrees to place the said number of tons of storage coal in storage on or before the following dates in amounts as follows:

....19........ ....tons.
....19........ ....tons.
....19... ... .tons.

BILLS OF LADING

XI. When requested by the Consumer, the Company shall show the Consumer the original bills of lading of cars from which coal is delivered hereunder.

STANDARDS

XII. All British thermal unit determinations under this contract shall be made by a Mahler Bomb Calorimeter, standardized against Cane Sugar, as obtained from the United States Bureau of Standards. The Thermometer used in connection with this Calorimeter shall be a Beckman Differential Thermometer, standardized by the United States Bureau of Standards, and their correction used.

TERM OF CONTRACT

The term of this contract shall be from the date hereof, to and including the...
day of...19..........

In Witness Whereof, the parties hereto have hereunto set their hands and seals, at...this ....
day of..,19........

....(SEAL)

ATTEST:...

....(SEAL)

ATTEST:...

HOW THE NET BRITISH THERMAL UNITS FOR ONE CENT IS FIGURED

The following is an example of how the B.t.u. for one cent is figured. Assuming the analysis to be as follows:

Moisture	10.5 per cent
Dry Ash	15.5 per cent
B.t.u. per lb. of Dry Coal	12160
Price	$1.65

12160 B.t.u. per pound dry
.105 Moisture in one lb. of coal
60800
12160
1276.800 B.t.u. lost due to moisture in coal

165.0 Price, expressed in cents,
7.7 One-half dry ash percentage expressed as cents, to off-set decrease in burning efficiency due to presence of ash.
172.7

12160 B.t.u.dry
1276 B.t.u. lost due to moisture in coal
10884 B.t.u. per lb. coal as delivered
2000 lb. per ton

172.7)21,768000 B.t.u. per ton as delivered
126045 Net B.t.u. for one cent

The "Net B.t.u. for One Cent" is the Contract Guarantee, as this is the amount of heat the coal contractor agrees to deliver for every cent paid.

HOW THE DELIVERED VALUE IS FIGURED

Assuming that a contract has been made on the following analysis data, which is the same as used in the above illustration:

Moisture	10.5 per cent
Dry Ash	15.5 per cent
B.t.u. per pound of dry coal	12,160
Price	$1.65
Contract Guarantee Net B.t.u. for One Cent	126,045

and that a sample of the coal delivered on this contract analyzed as follows:

Moisture	10.4 per cent
Dry Ash	14.5 per cent
B.t.u. per pound dry	12,330

the Delivered Value would be figured as follows:

12330 B.t.u. per pound dry
.104 Moisture in one lb. of coal

49320
12330

1282.320 B.t.u. lost due to moisture in coal
12330 B.t.u. per pound dry
1282 B.t.u. lost due to moisture in coal

11048 B.t.u. per lb. as delivered
2000 lbs. per ton
126,045)22,096,000 B.t.u. per ton as delivered
175.3
7.2 One half dry ash percentage expressed as cents to offset decrease in burning efficiency due to the presence of ash

168.1 cents, equal to $1.681, the delivered value

You will note in the above contract that the net B.t.u. for one cent is the contract guarantee, this being the amount of heat the coal contractor agrees to deliver for every cent paid. This particular illustration is adjusted for use in plants having chain grates, Roney or Murphy stokers. The fluctuation in price under this contract has been checked against the actual operation of a number of plants, and it is found that, by adding one-half the percentage of dry ash to the price as an offset for decrease in burning efficiency, that the cost of producing one thousand pounds of steam will remain constant. If this same contract were to be used in a hand-fired plant or any plant having an under feed stoker, it might be necessary to add more than one-half of the dry ash percentage to the price to offset the decrease in burning efficiency due to the presence of ash. Also in some cases it might be necessary to add as much as 65 per cent of the dry ash to the price in order to adjust the delivered value to the operation of the plant. The reason for this is that the increase in ash does much less damage where some mechanical stoker is in use than in a hand-fired plant or in an under feed stoker where the fires have to be cleaned by hand.

The net B.t.u. for one cent, in addition to being used as a contract guarantee, is of great value as a means of comparison, inasmuch as it takes into account the amount of moisture, ash and heat contained in the coal, as well as the price, thereby furnishing the best basis of comparison between different kinds of coal, reducing them to the same common denominator and showing at a glance which is the cheapest to purchase, providing the coal is suitable for plant operation. The following table shows a number of different bids received by one concern:

KIND OF COAL	MOISTURE	DRY ASH	DRY B.T.U.	PRICE	NET B.T.U. FOR ONE CENT.
Pocahontas Run of Mine (A).......	4.0	5.5	14,957	3.20	88,992
Yough. Screenings (B)............	6.0	12.2	13,466	2.75	90,067
Carterville Screenings (C)..........	10.5	15.5	12,160	1.65	126,045
Indiana Screenings (D)............	15.0	18.1	11,659	1.60	117,289

If the price only had been taken into consideration the purchaser would have made a mistake as the lowest price was not the cheapest coal (D). If the B.t.u. in the coal only had been taken into consideration the purchaser would have made another mistake as the coal of the highest B.t.u. is not the cheapest (A). As it was he used the net B.t.u. for one cent and purchased the kind of coal for which he could get the most heat for the money (C). If this coal had not been suitable for his plant conditions, of course, he could not have purchased it. His plant, however, was equipped in such a manner and had sufficient draft and boiler capacity to handle a coal of this grade.

My method of handling the purchase of a supply of fuel for a large plant, say 5000 h.p., is as follows: First, to determine by observation the size of coal we believe best suited to the operation conditions and then request bids from as many contractors as may be able to deliver at this particular plant, placing no restrictions on the quality of the coal they wish to bid upon, excepting as regards size. These bids are asked for upon our standard form of contract, the coal producer filling in the contract, showing exactly what he is willing to guarantee to deliver.

I wish to condemn the practice of basing the standard for future deliveries upon one analysis, particularly if the sample is furnished by the coal company. I know of a case two years ago where a consumer and coal contractor, both ignorant regarding the working of the heat value contract, used as a basis for guarantee an analysis of a sample taken from one load of coal. The analysis was in a sealed envelope and it was agreed to use it as the basis for future settlements without looking at it. The result was that the analysis being high caused the coal contractor to lose over $700 on the delivery of 12,000 tons of coal. The coal contractor to this day believes he was swindled and steadfastly refuses to bid upon the heat value basis again.

We then tabulate the bids and ascertain the one which will furnish us the greatest amount of heat for the money. If it becomes apparent that some quality in this coal is such that it is not advisable to use it, we then examine the next bid and continue until we find a bid which we believe is best suited to conditions. This coal we order in for trial and make a running test of several days' duration, calculating the cost of one thousand pounds of steam each day upon the delivered value of the coal received each day. The coal of course fluctuating some, the delivered value according to our system would hold the cost of one thousand pounds of steam constant. If this cost of steam is as low as we are entitled to expect, taking into consideration the location of the plant and its equipment, we accept the bid offered and proceed to sample each car of coal delivered under the contract. These samples so taken are composited each week, making four analyses per month, the average of these delivered values according to the terms of the contract being the settling price we pay. The coal contractor is given adequate opportunity to check up sampling and analyses and a method is provided in the contract for settling any disputes which may arise regarding the correctness of the delivered value. Over four million tons of coal have been purchased in this manner, including Pocahontas, New River, West Virginia Splint and Gas, Youghiogheny, Hocking, Pittsburgh No. 8, Kentucky Southeastern field, Kentucky Northwestern field, Indiana, all kinds, and Illinois, all kinds. This coal has been consumed upon almost every variety of mechanical stoker, shaking grates and ordinary hand-fired plants.

I will now proceed to give the results of a series of tests made on different kinds of coal at a large plant in Chicago. These, I believe, demonstrate clearly the point brought out in the basic principle which I suggest. The fluctuations in the quality of the coal must only alter the price such an amount as may be necessary to make the cost to the consumer of producing one thousand pounds of steam the same.

From the two sets of tests given above you will note that the cost of one thousand pounds of steam is practically constant. This is as we believe it should be.

Last January the American Society for Testing Materials appointed a committee of fifty members to draft standard coal specifications. The committee met in Pittsburg and discussed the subject at considerable length, sub-committees being appointed to carry out the work of investigation. I am serving as a member of the sub-committee on specifications for steam boiler plants and as chairman of the sub-committee on contract form of specifications. In connection with my work on these two committees I have examined a large number of heat value contracts and believe it will be of interest to this Association to submit the same to you for your consideration, commenting upon such as I deem unfair. The following are the paragraphs which pertain to the settling and quality feature, with a short comment on each.

Data and Results of Evaporative Tests

Test Number	3	4	5	6	14
Date of Test	Jan. 25	Jan. 26	Jan. 29	Mar. 12	Apr. 21
Duration of Test, hours	8.00	8.00	8.00	8.00	9.70
Kind of Furnace (Chain grate)					
Grate Surface, area sq. ft.	96.75	96.75	96.75	96.75	96.75
Kind of Boiler (Water Tube)					
Water Heating Surface, sq. ft.	5000	5000	5000	5000	5000
Number of Boiler in Service	1	1	1	1	1
Fuel					
Kind	1½″ Scr.	1½″ Scr.	1½″ Scr.	1½″ Scr.	1½″ Scr.
Origin, County	Williamson	Williamson	Williamson	Saline	Williamson
Size, per cent through ¼″ screen	37.20	32.80	38.50	25.20	....
Total wt., lb, as fired	20600	19200	21400	22233	24000
Total wt., lb, dry	18462	17395	19339	20063	20777
Pounds burned per sq. ft. of grate per hour, as fired	26.80	24.80	27.60	28.70	25.57
Pounds burned per sq. ft. of grate per hour, dry	23.90	22.50	25.00	25.90	22.14
Ash and refuse in coal as fired, pounds	2550	2348	2820	3237	2864
Ash and refuse in coal as fired, per cent	12.38	12.23	13.18	14.56	11.93
Water					
Fed to boiler, lb	147172	138880	154135	157152	163315
Factor of evaporation	1.1382	1.1321	1.1368	1.1199	1.1484
Equiv., from and at 212″° F.	167511	157226	175220	175995	187551
Average Pressures and Temperatures					
Steam gauge, lb	164.90	156.50	167.10	171.80	164.20
Feed water, °F	128.30	133.00	130.00	146.70	118.30
Flue gases, °F	459	475	493	476	462
Draft, inches of water, in furnace	.29	.25	.26	.28	.30
Draft, inches of water, in breeching	1.10	1.00	1.06	1.17	1.08
Horsepower					
Horsepower developed	607	570	635	638	563
Rated horsepower in service	500	500	500	500	500
Per cent of rated horsepower developed	121	114	127	128	113
Economic Results					
Equivalent evaporation from and at 212°F, as fired	8.13	8.19	8.19	7.92	7.81
Equivalent evaporation from and at 212°F, dry	9.07	9.04	9.06	8.78	9.03
Combined efficiency of boiler and grate	68.70	68.80	68.50	67.95	68.81
Cost of Steam					
Cost of coal, contract price cts.	165.5	165.5	165.5	165.5	165.5
Cost of coal delivered value cents	168.9	170.0	170.5	165.3	161.6
Cost of coal per 1000 lb. of steam	10.39	10.38	10.41	10.44	10.35
Analysis of Flue Gases					
Per cent of CO_2	6.4	7.6	7.4	7.4	7.6
Analysis of Coal					
Per cent of moisture	10.38	9.40	9.63	9.76	13.43
Per cent ash, dry coal	12.60	12.90	12.90	15.19	13.05
B.t.u. per pound, dry coal	12745	12697	12766	12491	12661
B.t.u. per pound, commercial	11422	11503	11537	11272	10961

Data and Results of Evaporative Tests.

TEST NUMBER		2	9	11	12	13
DATE OF TEST		Jan. 18	Mar. 26	Apr. 5	Apr. 13	Apr. 13
DURATION OF TEST, hours		8	7.62	5.75	7.97	7.42
KIND OF FURNACE (Chain grate				Chain Grate		
GRATE SURFACE, area sq. ft.		85.50	85.50	85.50	85.50	85.50
KIND OF BOILER (Water tube)				Water Tube		
WATER HEATING SURFACE, sq. ft.		3800	3800	3800	3800	3800
NUMBER OF BOILER IN SERVICE		14	14	14	14	14
FUEL						
Kind		1½″ Scr.	1½″ Scr.	1½″ Scr.	2″ Scr.	1½″ Scr.
Origin, County		Williamson	Williamson	Williamson	Perry	Williamson
Size, per cent thorough ¼″ scr.			34.21	36.69	37.50	
Total wt., lb.	as fired	20130	20000	14000	20000	20000
	dry	18894	17992	12673	18176	16676
Pounds burned per sq. ft. of grate per hour	as fired	29.40	30.70	28.48	29.35	31.53
	dry	27.60	27.61	25.78	26.67	26.29
Ash and refuse in coal as fired	pounds	3003	2249	1610	2890	2611
	per cent	14.92	11.25	11.50	14.45	13.06
WATER						
Fed to boiler, lb.		138359	140429	99257	128418	124860
Factor of evaporation		1.1251	1.1133	1.1033	1.1023	1.1211
Equivalent, from and at 212° F.		155668	156339	109510	141555	139980
AVERAGE PRESSURES AND TEMPERATURES						
Steam gauge, lb.		97.10	96.3	99.3	102.7	98.7
Feed water, °F.		129.70	140.8	150.9	152.7	133.7
Flue gases, °F.		709	631	600	617	589
Draft, inches of water	in furnace	.25	.31	.33	.36	.45
	under damper	.77	.77	.90	.94	.95
HORSEPOWER						
Horsepower developed		564	595	552	515	547
Rated horsepower in service		380	380	380	380	380
Per cent of rated horsepower developed		148	157	145	136	144
ECONOMIC RESULTS						
Equivalent evaporation from and at 212° F.	as fired	7.73	7.82	7.82	7.08	7.00
	dry	8.24	8.69	8.65	7.79	8.40
Combined efficiency of boiler and grate		65.60	65.42	65.64	65.02	64.90
COST OF STEAM						
Cost of coal, contract price cts		165.5	165.5	165.5	165.5	165.5
Cost of coal delivered value cts		166.3	171.0	169.9	152.5	152.7
Cost of coal per 1000 lb. of steam		10.74	10.93	10.86	10.91	10.91
ANALYSIS OF FLUE GASES						
Per cent of CO_2		7.5	8.2	7.9	7.9	8.1
ANALYSIS OF COAL						
Per cent of moisture		6.14	10.04	9.48	10.94	16.62
Per cent ash, dry coal		16.30	12.17	13.10	17.40	14.10
B.t.u. per pound, dry coal		12117	12832	12709	11808	12492
B.t.u. per pound, commercial		11373	11544	11504	10516	10416

CONTRACT A

EXTRACT FROM CONTRACT AND SPECIFICATIONS FOR SEMI-BITUMINOUS COAL FOR THE BOROUGH OF BROOKLYN

Clause 3, page 20, of the contract reads as follows: The coal required shall be merchantable and from well-known veins. The bituminous coal shall contain not less than 13,500 B.t.u. per pound. The heat units in the coal shall be determined by using the Mahler Bomb Calorimeter and the samples shall be taken when and where directed by the engineer. The contractor shall be notified when and where samples are to be taken, and may have a representative present, if he so desires, and if he considers that the sample taken is not a fair sample of the coal furnished, he shall file a written protest within twenty-four (24) hours after the time the sample is taken. The contractor may have a representative present during the test of the coal, if he makes written request within twenty-four (24) hours after the sample is taken, but such representative shall not interfere in any way in carrying on the test. The results of all tests shall be furnished to the Contractor when written request be made for the same. In making the analysis the amount of volatile sulphur present will be ascertained, with a view to determine the liability of spontaneous combustion, and the total amount of sulphur shall at no time exceed one and one-half per cent (1½ per cent) the calculations to be made in all cases on dry coal and by the method of ultimate analysis. The coal shall be of the best quality, clean, fresh-mined and free from dirt, slate and other impurities. The quality of the coal delivered must be uniform throughout the period of the contract, and it shall conform with the conditions herein specified. If at any time the quality of the coal should prove inferior to that herein described the Commission may and shall deduct such sum or sums from the estimated amount of money which would otherwise be due to the Contractor as fairly representing the loss caused to the party of the first part by reason of the depreciation in quality; and in case of failure to comply with any of the other terms of this contract after due notice shall have been given to the Contractor of such failure, the commission shall have the right to cancel the contract.

COMMENT

The terms of settlement under this contract are not definite enough. The acceptance of coal should never be left to any one person's judgment or discretion.

CONTRACT B

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, CITY OF PITTSBURGH

Department of Public Works

The class of coal which will be usually required at the station will be what is known to the trade as nut and slack, which is coal screenings resulting from the passing of a clean run of mine coal, of the grade required, over a screen having clear spaces of 1½ inches between the bars and nothing more. If the contractor should be unable, at any time, to deliver, when required, a sufficient quantity of the class of coal designated, by reason of causes beyond their control, then the contractor may supply any deficiency with lump or run of mine coal, at the contract price, which, however, must be broken up by the contractor, at his own expense, either before or after delivery, so as to be ready for immediate use, to such sizes as will enable it to pass easily through a 2½-inch slot in the feed hoppers of the automatic stokers in this station.

It is expressly understood and agreed that the fuel for this pumping station must be supplied continuously for twenty-four hours a day, and every day (three hundred sixty-five) of the year, in such quantities as the requirements of the station may demand, and any failure on the part of the contractor to deliver a sufficient quantity of the fuel called for by the contract daily, will entitle the City to procure forthwith any kind of fuel, at any price, in order to keep the station in operation, and any difference in the price of such fuel, over the contract price, must be paid by the contractor, and the city is hereby authorized to deduct such excess amounts from any amounts as may be due from the contractor for such excess cost, over and above such amounts as may remain at the time in the city's possession.

Bidders must submit, with proposal, a sample of the coal they propose to furnish, which sample will be tested by the city for heating value by the bomb calorimeter method of testing, or a method equally reliable. Tests will be made by the city, from time to time, by means of samples of coal, taken from the cars as delivered at the pumping station, or from the bin into which the coal may have been stored, to determine whether the coal furnished under this contract continues to meet the requirements specified as to calorific value, and should the coal delivered, at any time, run below 13,000 B.t.u. in heating value, then the city shall have the option either to reject all coal, as represented by the samples taken, or to accept the coal at a lesser price than that bid, which lesser price shall be reckoned at ten cents (10c) per ton, to be deducted for each one hundred heating units, or fraction thereof, which the heating value of the coal, as determined by the tests, runs below the 13,000 B.t.u. required.

All coal rejected shall be forthwith removed from the premises by the contractor and replaced promptly with other coal, which shall be up to the requirements of the specifications.

In cases of dispute between the contractor and the city's representative as the results obtained by the analyses of samples of coal which are made from time to time, the contractor shall have the right to have analyses made upon the same representative samples, and in case of further disagreement or dispute, the final analyses shall be made by a disinterested analyst, chosen by agreement of both parties, whose report shall be accepted by both parties as final.

COMMENT

Does not pay bonus. Deduction is more of a penalty than liquidated damages. Is not equitable.

CONTRACT C

EXTRACTS FROM CONTRACT AND SPECIFICATION, BITUMINOUS COAL IN USE BY COMPANY AT SAGINAW, MICHIGAN

3. The moisture in any car of coal as delivered will not exceed 10 per cent; the Ash will not exceed 14 per cent; the British thermal units will not be less than 12,000 per pound of dry coal nor less than 11,110 British thermal units per pound of coal (including moisture) as delivered.

4. Should any coal delivered hereunder contain more than the above mentioned percentage of Ash or Moisture, or less than the above mentioned British thermal units, the Consumer may at its exclusive option, accept or reject the same. If the Consumer rejects said coal, all expenses in connection with said rejection including demurrage, if any, shall be borne by the Company. If the Consumer accepts the coal, then the price for such coal shall be determined as follows:

One cent shall be deducted from the contract price per ton ($1.55) for each seventy British thermal units per pound of coal (including moisture) as delivered, which the coal (by test) falls short to the guaranteed minimum of 11,110 British thermal units per pound of coal (including moisture) as delivered.

Should any coal analyzed at the request of Consumer contain less than the last percentage of Ash or Moisture or more than the last above mentioned B.t.u.'s, then one cent shall be added to the contract price for each seventy B.t.u. per pound of coal as provided above.

No coal shall be tested for moisture that has been exposed in transit to excessive rain or snow. If such cars are tested, then the test to be made on dry coal and 12,000 British thermal units to the pound of dry coal to govern settlement.

5. Consumer may from time to time as it desires cause samples of coal to be collected, from the cars shipped, and analyzed. Should the analysis of these samples indicate that the coal as delivered is not up to the grade and quality specified in paragraphs Nos. 1 and 3 hereof, the Consumer shall notify the Company of the same, and an analysis of various samples shall be made by a fuel chemist and mutually agreed upon by the Consumer and the Company. This analysis shall be final and binding and a settlement for all coal under dispute shall be made on the basis of this analysis according to the terms of paragraph No. 4 of this contract.

6. Samples of coal for final analysis according to paragraph No. 5 shall be collected only by the Consumer's representative together with a representative of the company. It is agreed, however, that in case of failure of the Company to send within two days from date of notification its representative for the purpose of collecting said samples for analysis, or to name within three days from date of notification, a chemist whom it desires to make an analysis, of said samples, the Consumer may act alone in collecting and analyzing said samples and the terms of paragraph No. 5 shall hold.

COMMENT

Does not pay bonus. Otherwise fair. One cent for seventy B.t.u.is all right providing, the price of coal is high. Should be changed for each different price.

CONTRACT D

EXTRACT FROM CONTRACT AND SPECIFICATIONS FOR BITUMINOUS COAL, CITY OF MINNEAPOLIS, MINNESOTA.

This contract is pratically the same as the contract I propose, except paragraphs 6 and 7, which are as follows: "It is understood that coal delivered hereunder be superior in quality to contract grade, so that the price per ton, figured as set forth in paragraph 3 below, exceed the price per ton of "Contract Grade," no excess over the price per ton of Contract Grade will be paid, but in lieu thereof the excess earned that month will be "credited in favor of the Company" and applied to the "liquidation of any penalty" which would otherwise be enforced, for a deficiency in any month, or months hereunder, should any such deficiency exist, as shown by the analysis.

7. To determine the quality of coal delivered and accepted hereunder it is agreed that the Consumer shall cause to be collected, and analyzed, at its own expense, by its Fuel Agent, the City Chemist of Minneapolis, fair average samples of coal delivered hereunder, not less than once each week, and the results promptly reported to the Company together with its delivered values. The Company may have a representative present at the time of selecting any or all of these samples, and when requested by the company such samples shall be divided into three (3) parts, one part given to the Consumer, one to the Company, and the third sealed in the presence of the representatives of both, and kept by the Consumer. If the Company so requests in writing within five (5) days after the receipt of the Consumer's analysis, the third (sealed part) of the sample, shall be delivered to a chemist of high standing, to be mutually agreed upon and analyzed at the expense of the Company, and this analysis shall be final and binding.

COMMENT

Same as our standard contract, but does not pay a bonus. This is not right and should be changed.

CONTRACT E

EXTRACT FROM CONTRACT AND SPECIFICATIONS FOR BITUMINOUS COAL, METROPOLITAN WATER AND SEWERAGE BOARD, BOSTON, MASS.

Coal must be good run-of-mine bituminous coal, free from dirt and excessive dust, a dry sample of which will approximate the following standard of heat value and analysis; B.t.u. 14,200, volatile matter 18 to 20 per cent, ash 8 per cent, sulphur 1 per cent. Coal which, when dry, contains more than 14 per cent of ash, 23 per cent of volatile matter or 1.75 per cent of sulphur may, at the option of the Chief Engineer of the Metropolitan Water Works be rejected, and if rejected shall be removed by and at the expense of the contractor. Payments for the coal shall be made on the basis of the price named in the proposal, corrected for variations in heating value and percentages of ash as follows: For each fifty thermal units or fractions thereof in excess of 14,200 the price per ton shall be increased 1½ cents, and for each fifty thermal units of fraction thereof less than 14,000 the price shall be decreased 1½ cents. For each ½ of 1 per cent or fraction thereof of ash in excess of 9 per cent the price per ton shall be decreased 1 cent. Samples of coal from each carload received shall be taken by a representative of the Metropolitan Water and Sewerage Board, and shall be tested at the laboratory of the Board under the direction of the Chief Engineer of the Water Works, and the results of these tests shall be made in determining whether the coal shall be accepted, and in determining the corrections to be made in the price named in the proposal.

COMMENT

Fair plan, but must be adjusted to fit price. Present adjustment well suited for a coal for $5.00 or $6.00 a ton, but would not do at all on a coal worth $1.50.

CONTRACT F

EXTRACT FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, CITY OF ST. LOUIS.

Coals to have a calorific value as follows: Screened lump to have a calorific value of beween 10,000 and 11,000 British thermal units per pound of coal. One and one-half inch screenings to have a calorific value of between 9500 and 10,500 British thermal units per pound of coal. The prices paid for coal showing a higher calorific value than specified above, shall be greater than the contract price by *one-half of 1 per cent* of the contract price for every 100 B.t.u. that the calorific value is above the maximum calorific values called for above; the price paid for coal showing a less calorific value than that above specified, shall be less than the contract price, by 1 *per cent* of the contract price for every 100 B.t.u. that the coal falls in calorific value below the minimum calorific value called for above. All percentages of increase or decrease will be calculated only by steps of 100 B.t.u.; values less than 100 B.t.u. will be estimated as 100 only when they are over 50.

All determinations of calorific value will be made by the Water Department from samples taken from each car, using the Parr Calorimeter with no correction for moisture.

COMMENT

This contract well adjusted for coal used. Not suitable elsewhere.

CONTRACT G

EXTRACTS FROM CONTRACT AND SPECIFICATIONS BITUMINOUS COAL W. A. MARSHALL & CO., NEW YORK.

Kinds of Coal

There shall be furnished a good steam, caking, run of mine, bituminous coal, free from all dirt and excessive dust, a dry sample of which will approximate the standard in heating value and analysis, as given below under "Standard Coal."

Chemist

A disinterested chemist, to be mutually agreed upon, shall make all analyses at the expense of the buyer, and his report shall be binding upon both parties.

The chemist's report on this sample shall constitute the basis for settlement for all deliveries represented by the sample, except as hereinafter provided.

Should the Contractor dispute the results as obtained by the Buyer's chemist, it is hereby agreed that the second sample provided for above shall be tested by analysis by a chemist agreed upon by both parites, and the result so obtained shall be final and govern the price to be paid for the coal, as per table of specification.

The second test, if made, shall be at the expense of the Buyer, in case their first results shall be found in error more than 2 per cent, otherwise the expense shall be borne by W. A. Marshall and Company.

Analysis

All analyses shall be made by the method adopted by the American Chemical Society and using a bomb calorimeter.

Sampling

At least three samples will be taken out of every carload or cargo—at the beginning, middle and end of the run—immediately after the coal leaves the car or cargo; these samples will be large enough to give an average of the fine and coarse coal as it runs. These samples will be immediately placed in a clean, covered receptacle. Once each week, or at such other times as may be mutually agreed upon, the samples so preserved will be thoroughly mixed, broken down and reduced, by quartering, to a laboratory sample, which will be immedately forwarded, in a sealed jar, to the chemist for analysis and test, and a portion of each laboratory sample will be furnished to the contractor for check analysis, if he so requests, said second sample to be saved for a period of ten days after the results of the first tests are given.

Standard Coal

The Buyer will accept, at the contract price hereafter named, any coal, a dry sample of which approximates as follows:

Volatile Combustible matter, not over	22 per cent
Ash	8.5 to 9
Sulphur (by separate analysis)	1.5
B.t.u. per pound	14,200 to 14,250

Deductions and Premiums

Any coal showing more than 22 per cent of volatile combustible matter shall be subject to a deduction of 2 cents per ton for each ½ of 1 per cent or fraction thereof above 22 per cent.

Any coal showing less than 8½ per cent ash shall receive a premium of 2 cents per ton for each ½ of 1 per cent or fraction thereof below 8½ per cent.

Any coal showing more than 9 per cent shall be subject to a deduction of 2 cents per ton for each ½ of 1 per cent or fraction thereof above 9 per cent.

Any coal showing less than 1.5 per cent in sulphur shall receive a premium of 2 cents per ton for each ¼ or 1 per cent or fraction thereof less than 1.5 per cent.

Any coal showing more than 1.5 per cent sulphur shall be subject to a deduction of 2 cents per ton for each ¼ of 1 per cent or fraction thereof above 1.5 per cent.

Any coal showing more than 14,250 B.t.u. per pound shall receive a premium of 1 cent per ton for each 50 B.t.u. or fraction thereof above 14,250. Thus, coal showing 14,351 to 14,400 B.t.u. per pound shall receive a premium of 3 cents per ton.

Any coal showing less than 14,200 B.t.u. per pound shall be subject to a deduction of 1 cent per ton for each 50 B.t.u. or fraction thereof below 14,200. Thus, coal showing 14,000 to 14,050 B.t.u. per pound shall be subject to a deduction of 4 cents per ton.

Rejections

Should any coal be offered which contains more than 15 per cent ash, or more than 3 per cent sulphur, or more than 26 per cent volatile matter, or less than 12,500 B.t.u. per pound, the Buyer may, at its option, refuse to receive or unload it.

COMMENT

Clever contract drawn from coal dealer's point of view. Very seductive. Standard so fixed that coal would earn bonus and steam cost would be high. The coal company who uses this form of contract was the first to come out heartily in favor of the purchase of coal upon heat value specifications.

CONTRACT H

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, CITY OF CLEVELAND

Quality

26. The coal to be clean, free from stone, slate and other impurities and equal in all respects to the best products of the mine from which it was produced, and to the sample furnished.

It is to be fresh mined, dry burning coal.

27. Coal that melts or adheres to the grates will not be accepted.

Coal Samples to be Furnished

28. Each bidder will be required to furnish a sample carload of the different kinds of coal he proposes to furnish, and shall, if required, furnish all coal necessary for operating the pumping stations for from one to three weeks, in order to test the coal.

Analyses and Tests

29. Chemical analyses and evaporative or calorimeter tests, or all, will be made of the sample coal furnished before entering into contract, in order to determine its heating value, and the percentage of moisture and ash contained in said coal.

Standard

30. The calorific value of the sample coal submitted by the contractor as determined by the Superintendent, shall be the standard of all coal to be furnished under the contract.

Reduction of Price for Inferior Coal

31. Each car of coal furnished by the contractor during the continuation of any contract that may be entered into shall be sampled by the Superintendent or his authorized agent and tested to determine its heating value, and if the coal shall be found to be of a quality inferior to the sample coal furnished for tests, or shall show greater percentage of ash and moisture and a smaller amount of heat units, the price to be paid for said coal shall be reduced as follows:

A settlement shall be made for coal delivered each month and all coal having a heat value of less than 12,000 B.t.u. per pound of coal, shall be put in a class by itself and a reduction shall be made in the price paid for such coal equal to three (3) cents per ton for each 100 British thermal units or fraction thereof that the coal in this class falls below the standard. The average calorific value of all other coal delivered during each month shall be determined, and if this average falls below the standard, the price to be paid therefor shall be reduced at the rate of 1½ cents per ton of coal for each 100 British thermal units or fraction thereof that the average monthly calorific value of the coal furnished falls below the standard.

A corresponding increase in the price to be paid for the coal shall be made in case the average monthly heat value of the coal furnished is above the standard.

Superintendent to be Final Judge

32. The Superintendent is hereby made the final judge as to whether the coal furnished under this contract is of the quality stipulated herein.

Weighing of Coal

33. The railroad company's weights, as shown in their certified statement, shall be accepted and bills paid for at said weights. The City, however, reserves the right, at its own expense, to have any or all cars or coal weighed, both loaded and light, on the city's track scales at the pumping stations, and to pay for the coal in accordance with these weights instead of accepting the weights shown on the certified statements.

Use of Coal from Stock Pile

40. In case of failure to supply such quantities or kinds of coal as herein specified and contracted for, and as ordered by the Superintendent, the right is reserved to use coal from the stock piles, or to purchase at once such quantities of coal as may be needed, at the market rates. The additional expense of such use of coal from stock piles, and the increase in cost and expense of coal purchased, if any there be, shall be paid by the contractor before any payments for coal delivered shall be made by the city.

Contractor to Replace Coal in Stock Pile

42. If at any time coal has been taken from the stock piles at the pumping stations, on account of the failure of the contracting parties to deliver the required quantities daily, an equal amount of coal must be replaced in said stock piles by the contractor immediately upon receipt of written notice from the Superintendent so to do.

When Board May Purchase Coal or Annul Contract

43. In case of failure to comply with said notice, or if in the opinion of the Board of Public Service the contractor fails to supply coal in such quantity and of such quality as hereinbefore stipulated, or if the contractor from shall furnish coal mines other than those stipulated in the contract, the Board of Public Service shall have the right to purchase coal in such quantities as may be needed, at the market rates, in the open market, and to collect the increase in cost and expense, if any there be, from the contractor, and furthermore, the said Board of Public Service shall have the right to annul and cancel this contract and relet the work, and the said contractor shall not be entitled to any claim for damages on account of such annulment, nor shall such annulment affect the right of this city to recover damages which may arise from such failure on the part of the contractor to fulfill the terms of his contract.

COMMENT

Settlement method too erratic, making cost of producing steam fluctuate greatly.

CONTRACT I

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, CITY OF CHICAGO

All proposals for coal hereunder must be made on forms furnished by the Commissioner of Public Works. All data called for on same shall be carefully and accurately furnished. Each proposal shall be accompanied by a certified check or certificate of deposit made payable to the order of the Commissioner of Public Works of the City of Chicago, or by currency, in the amount of $5000, which deposit will be returned to the bidder if such proposal is rejected, or, if such proposal is accepted, the bidder must, within five days of the date of notification that said contract and bond are ready for execution, enter into contract with the City of Chicago, giving a bond in a sum equal to the amount of the contract for the satisfactory performance of same. Should the bidder fail to enter into said contract and furnish said bond within said five days, the said deposit is to be forfeited to the City of Chicago as liquidated damages.

4. Bidders are required to warrant the trade name, the name of the mine and vein, county and state in which the coal is to be mined, the per cent of fixed carbon, the per cent of volatile combustible matter, the per cent of ash, the per cent of moisture, the per cent of sulphur in the coal as it is delivered, and the number of British thermal units contained in each pound of dry coal.

5. Bidders shall also in each and every case specify the average number of pounds of water from and at 212 degrees Fahr. that each pound of dry coal will evaporate at the particular place to which each bid refers, and such guaranteed evaporation must be maintained during the life of the contract that may be entered into with the successful bidder.

6. All tests shall be made by the regular employees of the City under the direction of the Commissioner of Public Works. The coal is to be weighed on the scales at the pumping stations and the water is to be measured and weighed in tanks. Should any coal under the tests made as above described fail to develop the average efficiency guaranteed, then the City will make a reduction from the contract price for the particular coal tested in the same ratio that the average evaporation as determined by such tests bears to the guaranteed average evaporation.

7. In calculating this evaporation, correction shall be made for any superheating which may be done by a superheater which is part of any boiler equipment.

8. The City will make evaporation tests as often and of such duration as may be deemed necessary to insure the proper quality of coal at all times. The boilers used in such tests shall be clean and in good condition.

9. The contractor will be allowed to have a representative present during tests, but will not be permitted to control or direct while such tests are being made. The City's employee in charge of the tests shall have full control of all operations in connection with such tests. The City will notify the contractor two days before the test is to be made so that he can arrange to have a representative present during the test.

10. When requested by the Commissioner of Public Works, bidders shall furnish and deliver to one of the City Pumping Stations, as designated by the Commissioner of Public Works, one wagon load of the coal bid upon, which coal shall be equal in all respects to the above warranties. and the City reserves the right to cause such coal to be analyzed, and if it fails to come up to the proposal warranties, to reject such proposal.

11. All deliveries of coal under contract shall be equal in all respects to proposal warranties and the sample, if any, of coal delivered upon request of the Commissioner of Public Works, which warranties and sample, if any, shall be known as the contract grade of coal.

12. In addition to making the evaporation tests as above specified, the City will at irregular intervals select fair samples of the coal to determine whether the coal delivered is up to the contract grade by the chemical analyses and calorimeter tests.

13. Should any coal fail to come up to the contract grade in respect to size, the City may refuse to accept same, and the contractor shall remove same without expense to the city, if ordered to do so by the Commissioner of Public Works.

14. Should any coal, upon inspection, be found to contain a greater amount of slate or sulphur or objectionable matter than is specified for the contract grade of coal, the City may reject such coal, and the contractor shall remove same without expense to the City, if ordered to do so by the Commissioner of Public Works.

15. When, for any reason, evaporation tests cannot be satisfactorily made, or the Commissioner of Public Works prefers the analytical test method should any coal upon analysis be found to be inferior in heat value to the contract grade, the City may refuse same, and at its option abrogate the contract, or it may accept same and pay for such inferior coal such a reduced price as shall make such inferior coal equal in heat value to the city to the contract grade.

16. This heat value (B.t.u. for one cent) shall be determined as follows: Multiply the number of British thermal units per pound of dry coal by the percentage of moisture, and subtract the number so found from the number of British thermal units per pound of dry coal. The result will be the number of British thermal units in one pound of coal as delivered. Multiply the British thermal units in one pound of coal as delivered by 2000 (to ascertain the British thermal units per ton) and divide this product by the price of the coal per ton expressed in cents. The results will be the net British thermal units for one cent.

17. The city shall mail to the contractor a copy of each evaporation test and analysis that it makes upon coal delivered by the contractor to the City.

18. The Commissioner of Public Works reserves the sole right to determine whether the person or persons designated for the purpose have made such inspections and tests in a proper manner, and, in case of any dispute as to the results of tests, the Commissioner of Public Works shall be sole judge, and his decision shall be final and binding.

19. Bills of lading, or other documents acceptable to the City, show-

ing the point of origin of the coal, road over which it was shipped, and date of shipment, are to be furnished to the City upon request, together with itemized bill for coal; the coal to be paid for at City weights. Two thousand pounds (2000) avoirdupois shall constitute a ton.

COMMENT

Do not favor evaporative test unless efficiency is guaranteed. The heat value section of the contract is very good, but does not correct for ash. The city does not use this method to purchase coal on the basis of evaporative test.

CONTRACT J

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL IN USE BY COMPANY IN BIRMINGHAM, ALA.

All coal delivered shall approximate in heat value and chemical analysis the following:

Fixed Carbon	58.65
Volatile matter	28.50
Ash	12.00
Moisture	.85
	100.00
Sulphur	.80

British thermal units 13,000 per pound of coal

8. All coal delivered under this contract is to be weighed on the scales of the railroad company at its power station, and such weights shall be final and conclusive between the parties, but the Coal Company, or its representative, may witness the weighing of all coal, and may also be present when the scales of the railroad company are calibrated.

9. All coal delivered and accepted under this contract will be paid for by the railroad company at a price per ton determined by taking the average of the value of the British thermal units obtained from an analysis of all samples of coal during each calendar month.

11. If the average of the value of the British thermal units obtained from the analysis of all samples of coal delivered during any calendar month shall vary from 13,000 British thermal units per pound of coal, then in that event the price shall vary in the proportion that the British thermal units, as shown by the said analysis of said coal as delivered, bears to the British thermal units of the contract and declining with a decline in British thermal units. The price per ton will be further corrected for the percentage of Ash, as shown from the said analysis of the coal delivered, in accordance with the following table:

Over 7 p. c. and less than 8 p. c., 9 cts. per ton premium
Over 8 p. c. and less than 9 p. c., 6 cts. per ton premium

Over 9 p. c. and less than 10 p. c., 3 cts. per ton premium
Over 10 p. c. and less than 11 p. c. No correction
Over 11 p. c. and less than 12 p. c. No. correction
Over 12 p. c. and less than 13 p. c., 3 cts. per ton deduction
Over 13 p. c. and less than 14 p. c., 6 cts. per ton deduction
Over 14 p. c. and less than 15 p. c., 9 cts. per ton deduction
Over 15 p c. and less than 16 p. c., 12 cts. per ton deduction
Over 16 p. c. and less than 17 p. c., 15 cts. per ton deduction
Over 17 p. c. and less than 18 p. c., 18 cts. per ton deduction

But if any coal is delivered which contains by analysis more than 18 per cent of ash, the railroad company shall have the right, at its option, to reject the same. The price will be further corrected from the percentage of sulphur as shown from the analysis of the coal as delivered in accordance with the following table:

Over .75 p. c. and less than 1.00 p. c. No correction
Over 1.00 p. c. and less than 1.25 p. c., 5 cts. per ton deduction
Over 1.25 p. c. and less than 1.50 p. c., 10 cts. per ton deduction
Over 1.50 p. c. and less than 1.75 p. c., 15 cts. per ton deduction
Over 1.75 p. c. and less than 2.00 p. c., 20 cts. per ton deduction

But if any coal is delivered which contains by analysis more than 2 per cent of sulphur, then the railroad company, in that event, shall have the right, at its option, to reject the same.

And in that event the coal is delivered in other than drop-bottom cars, the railroad company will make a further reduction in price of 5 cents per ton.

12. Samples of the coal as delivered will be taken by a representative of the railroad company. In all cases where practicable the coal will be sampled at the time of its being delivered to the building, and samples taken will in no case be less than a total of 100 pounds, to be selected proportionately from the lumps and fine coal, in order that it may in every respect truly represent the quality of coal under consideration. In order to minimize the loss of original moisture conditions, the gross sample will be pulverized as rapidly as possible until none of the fragments exceed one-half-inch (½) in diameter. The fine coal will then be mixed thoroughly and divided into four equal parts; opposite quarters will be thrown out and the remaining portions thoroughly mixed and again quartered, throwing out opposite quarters as before. This process will be continued as rapidly as possible until the final sample is reduced to such amount that all of the final sample thus obtained will be contained in a shipping can or jar and sealed air-tight.

If desired by the coal company, permission will be given its representative to be present during the preparation, and witness the preparation of the final sample to be forwarded to the laboratory.

13. Analysis of samples taken from the average sample will be made by the railroad company's chemist, under the supervision of the Superintendent of the Power House, or at any reliable and established chemical laboratory the railroad company may select, at its option Copies of all

analyses will be furnished by the railroad company to the coal company by mailing the same, postage prepaid. In the event the Coal Company raises no question of the correctness of the analysis within three days after the same is mailed, then the average sample of coal from which the analysis shall have been made will be destroyed, and the analysis so made and reported will be final and conclusive between the parties.

Should the Coal Company question the correctness of any analysis, the railroad company will, if requested by the Coal Company within three days after a copy of such analysis has been mailed to it, forward a sufficient quantity of the average sample taken from each car to any laboratory which may be agreed upon by the Superintendent of the Power House and the Coal Company, and will have the said sample analyzed, and the result so obtained from such second analysis shall be final and conclusive between the parties. In the event the second analysis shall vary more than 2 per cent from the first analysis, then the cost of the second analysis shall be borne by the railroad company, but otherwise the cost of such analysis shall be borne by the Coal Company.

14. This contract may be terminated on the thirtieth day of September, 1908, upon 30 days' notice given by the railroad company August 31, 1908, to that effect, if as a result of a practical service test of 30 days' duration, the coal delivered by the Company fails to give satisfactory results in the operation of the railroad company's power plant on account of excessive clinkering or an excessive amount of smoke, or other causes beyond the control of the railroad company.

And the railroad company shall have the right, at any time during the period covered by this contract, to cancel the same for any of the following several causes, to wit:

(*a*) If coal containing an excess of 18 per cent of ash shall be delivered with such frequency, or in such quantities as in the judgment of the railroad company seriously impairs the operation of its power plant.

(*b*) If coal is delivered by the Coal Company containing an excess of dirt, slate or fine dust, with such frequency, or in such quantities as in the judgment of the railroad company seriously impairs the operation of its power plant.

(*c*) If coal is delivered by the Coal Company containing 2 per cent or more of sulphur with such frequency or in such quantities as in the judgment of the railroad company seriously impairs the operation of its power plant.

(*d*) If coal containing less than 26 per cent of volatile matter is delivered by the coal company with such frequency, or in such quantities as in the judgment of the railroad company seriously impairs the operation of its power plant.

COMMENT

This contract makes too great a correction for the amount of damage done as shown by the cost of steam.

CONTRACT K

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, AMERICAN CAN COMPANY

Analysis of Coal to be Furnished by Seller

Black Creek Mine Run

B. t.u.	13100
Moisture	4.00
Volatile Matter	35.34
Carbon (fixed)	54.60
Ash	5.43
Sulphur	——

It is agreed by seller that coal furnished under contract will approximate the above analysis.

Failure to provide coal of approximate quality to the above, furnishes the right to buyer to reject at seller's expense such coal, which by analysis exceeds in ash the above by 4 per cent moisture by 4.50 per cent sulphur by 1.50 per cent B.t.u. less by 600 than specified above for contract grade.

All coal delivered under this contract, which, according to analysis, contains more than the specified per cent of ash and moisture, and less than the B.t.u. per pound dry, will be penalized as follows:

Ash

For each 1 per cent or fraction of 1 per cent of ash above, 6.00 per cent, 1 per cent of delivered price will be deducted from invoice price.

Moisture

For moisture above 4.50 per cent 1¼ per cent delivered price will be deducted from invoice price.

British Thermal Units

For each 125 B.t.u. or fraction thereof, less than 12850 1¼ per cent of delivered price shall be deducted from invoice price.

Premiums will be allowed as follows on basis per pound dry:

Ash

For each 1 per cent or fraction thereof of Ash under 5.00 per cent 1 per cent of delivered price will be added to invoice price.

Moisture

For each per cent or fraction of a per cent of moisture below 3.50 percent 1¼ per cent of delivered price will be added to invoice price.

British Thermal Units

For each 125 or fraction thereof, greater than 13350 1¼ per cent of delivered price will be added.

COMMENT

Method poor. Fitted only for one condition.

CONTRACT L

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, UNITED STATES GOVERNMENT

Coals containing more than the following percentages, based upon dry coal, will not be considered:

Ash . . . .per cent
Volatile . . . .per cent
Sulphur . . . .per cent
Dust and fine coal as delivered at point of consumption . . . .per cent

Causes for Rejection.

A contract entered into under the terms of this specification shall not be binding if, as the result of a practical service test of reasonable duration, the coal fails to give satisfactory results due to excessive clinkering, or to a prohibitive amount of smoke.

It is understood that the coal delivered during the year will be of the same character as that specified by the contractor. It should, therefore, be supplied, as nearly as possible, from the same mine or group of mines.

Coal containing percentages of volatile matter, sulphur, and dust higher than the limits indicated on page —, and coal containing a percentage of ash in excess of the maximum limits indicated in the following table will be subject to rejection.

In the case of coal which has been delivered and used for trial, or which has been consumed or remains on the premises at the time of the determination of its quality, payment will be made therefor at a reduced price computed under the terms of this specification.

Occasional deliveries containing ash up to the percentage indicated in the column of "Maximum limits for ash," on page —, may be accepted. Frequent or continued failure to maintain the standard established by the contractor, however, will be considered sufficient cause for cancellation of the contract.

Price and Payment

Payment will be made on the basis of the price named in the proposal for the coal specified therein, corrected for variations in heating value and ash, as shown by analysis, above and below the standard established by contractor in this proposal. For example, if the coal contains two (2) per cent, more or less, British thermal units than the established standard, the price will be increased or decreased two (2) per cent accordingly.

The price will also be further corrected for the percentages of ash. For all coal which by analysis contains less ash than that established in this proposal a premium of 1 cent per ton for each whole per cent less ash will be paid. An increase in the ash content of two (2) per cent over the standard established by contractor will be tolerated without exacting a penalty for the excess of ash. When such excess exceeds two (2) per cent above the standard established, deductions will be made from price paid per ton in accordance with following table:

ASH AS ESTABLISHED IN PROPOSAL.	NO DEDUCTION FOR LIMITS BELOW	CENTS PER TON TO BE DEDUCTED.							MAXIMUM LIMITS FOR ASH.
		2	4	7	12	18	25	35	
		Percentages of Ash in Dry Coal.							
Per cent									
5...........	7	7– 8	8– 9	9–10	10–11	11–12	12–13	13–14	12
6...........	8	8– 9	9–10	10–11	11–12	12–13	13–14	14–15	13
7...........	9	9–10	10–11	11–12	12–13	13–14	14–15	15–16	14
8...........	10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	14
9...........	11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	15
10...........	12	12–13	13–14	14–15	15–16	16–17	17–18	....	16
11...........	13	13–14	14–15	15–16	16–17	17–18	18–19	....	16
12...........	14	14–15	15–16	16–17	17–18	18–19	19–20	....	17
13...........	15	15–16	16–17	17–18	18–19	19–20	20–21	....	18
14...........	16	16–17	17–18	18–19	19–20	20–21	21–22	....	19
15...........	17	17–18	18–19	19–20	20–21	21–22	....	....	19
16...........	18	18–19	19–20	20–22	21–22	22–23	....	....	20
17...........	19	19–20	20–21	21–22	22–23	....	....	....	21
18...........	20	20–21	21–22	22–23	....	....	....	....	22

*NOTE.—The economic value of a fuel is affected by the actual amount of combustible matter it contains, as determined by its heating value shown in British thermal units per pound of fuel, and also by other factors, among which is its ash content. The ash content not only lowers the heating value and decreases the capacity of the furnace, but also materially increases the cost of handling the coal, the labor of firing, and the cost of the removal of ashes, etc.

Proposals to receive consideration must be submitted upon this form and contain all of the information requested.

....

....,190.............

The undersigned hereby agree to furnish to the U. S.................................. ....building at.. the coal described, in tons of 2240 pounds each and in quantity, 10 per cent more or less than that stated on page 1, as may be required during the fiscal year ending June 30, 190——, in strict accordance with this specification; the coal to be delivered in such quantities and at such times as the Government may direct.

Price per ton (2240) pounds ....$...............
Commercial name of the coal..
Name of the mine or mines..
Location of the mine or mines...
Name or other designation of the coal bed or vein...
Size (indicate information which will apply)...
Unsized...............................Lump...........................Run of Mine.......................
(Round)
Screened, through...................inch and over................inch (Square) Opening
(Bar Screen)

Data to establish a basis for payment:

BRITISH THERMAL UNITS IN COAL AS DELIVERED..

ASH IN DRY COAL (Method of American Chemical Society)................per cent.

It is important that the above information does not establish a higher standard than can be actually maintained under the terms of the contract; and in this connection it should be noted that the small samples taken from the mine are invariably of higher quality than the coal actually delivered therefrom. It is evident, therefore, that it will be to the best interests of the contractor to furnish a correct description with average values of the coal offered, as a failure to maintain the standard established by contractor will result in deductions from the contract price, and may cause a cancellation of the contract, while deliveries of a coal of higher grade than quoted will be paid for at an increased price.

Signature: ....

Address:...

Name of corporation ....

Name of president ....

Name of secretary ....

Under what law (State) corporation is organized:..

COMMENT

The ash penalty in this contract is figured on the wrong basis, as the same deduction would be made for a cheap coal as for an expensive one. It also grants a certain leeway before deductions are made. I do not think this is right, as whatever loss is sustained should be corrected for.

CONTRACT M

EXTRACTS FROM CONTRACT AND SPECIFFICATIONS, BITUMINOUS COAL, AMERICAN BRIDGE WORKS

Kind of Coal

Coal must be a good steam, coking, run-of-mine, bituminous coal, free from dirt, slate, and excessive dust, a dry sample of which will approximate the buyer's standard in heat value and analysis as follows:

Carbon	69
Volatile Matter	22
Ash	9.0
B.t.u.	14,250.
Sulphur	1.50

Deductions

Coal which is shown by analysis as herein provided to contain less than twenty-two per cent of volatile matter, nine per cent of ash, or 1.50 per cent of sulphur will be accepted without a deduction from the contract price, plus or minus an amount for excess of B.t.u. value, as hereinafter provided. Where the analysis gives amounts for any or all elements in excess of these quantities, deductions will be made from the price to be paid, in accordance with the following table of value or volatile matter, ash, and sulphur, plus or minus the amount for excess or deficiency of the standard B.t.u. value, in addition to any other deductions which may be made as herein provided.

Table of Volatile Matter

For coal in any car which is found by test to contain per pound of dry coal:

	Per ton.
Over 22 p. c. and less than 22.5 p. c.	2¢
22.5 p. c. and over, and less than 23.0 p. c.	4¢
23.0 p. c, and over, and less than 23.5 p. c.	6¢
23.5 p. c. and over, and less than 24.0 p. c.	8¢
24.0 p. c. and over, and less than 24.5 p. c.	10¢

Table of Ash

For coal in any car which is found by test to contain per pound of dry coal.

	Per ton.
Over 9.0 p. c. and over, and less than 9.5 p. c	2¢
9.5 p. c. and over, and less than 10.0 p.c.	4¢
10.0 p. c. and over, and less than 10.5 p. c.	6¢
10.5 p. c. and over, and less than 11.0 p. c.	8¢
11.0 p. c. and over, and less than 11.5 p. c.	10¢
11.5 p. c. and over, and less than 12.0 p. c.	12¢
12.0 p. c. and over, and less than 12.5 p. c.	14¢
12.5 p. c. and over, and less than 13.0 p. c.	16¢
13.0 p. c. and over, and less than 13.5 p.c.	18¢
13.5 p. c.	23¢

Table of Sulphur

For any coal in any car which is found by test to contain per pound of dry coal:

	Per ton.
Over 1.50 p. c, and over, and less than 1.75 p. c.	5¢
1.75 p. c. and over, and less than 2.00 p. c.	6¢
2.00 p. c. and over, and less than 2.25 p.c.	7¢
2.25 p. c. and over, and less than 2.50 p.c.	9¢
2.50 p. c. and over	12¢

Payments

For and in consideration of the true and faithful performance by the seller of each and every covenant and agreement on its part herein contained the buyer hereby undertakes and agrees to pay the seller on or before the twenty-fifth day of each month, the value of the coal delivered during the next preceding calendar month at the rate of .... dollars per long ton of

2240 pounds of standard coal between 14,201 and 14,250 B.t.u., both inclusive, according to the following table of values, but subject to any and all deductions as herein provided.

B.t.u. Table of Values

For coal in any car which is found by test to contain per pound of dry coal, from

Per ton above standard.	
15501 and above	26¢
15451 to 15500, both inc.	25¢
15401 to 15450	24¢
15351 to 15400	23¢
15301 to 15350	22¢
15251 to 15300	21¢
15201 to 15250	20¢
15151 to 15200	19¢
15101 to 15150	18¢
15051 to 15100	17¢
15001 to 15050	16¢
14951 to 15000	15¢
14901 to 14950	14¢
14851 to 14900	13¢
14801 to 14850	12¢
14751 to 14800	11¢
14701 to 14750	10¢
14651 to 14700	9¢
14601 to 14650	8¢
14551 to 14600	7¢
14501 to 14550	6¢
14451 to 14500	5¢
14401 to 14450	4¢
14351 to 14400	3¢
14301 to 14350	2¢
14251 to 14300	1¢
14201 to 14250	Standard
Per ton below standard.	
14151 to 14200	1¢
14101 to 14150	2¢
14051 to 14100	3¢
14001 to 14050	4¢
13951 to 14000	5¢
13901 to 13950	6¢
13851 to 13900	7¢
13801 to 13850	8¢
13751 to 13800	9¢
Per ton below standard.	
13701 to 13750, both inc.	10¢
13651 to 13700	11¢
13601 to 13650	12¢
13551 to 13600	13¢
13501 to 13550	14¢
13451 to 13500	15¢
13401 to 13450	16¢
13351 to 13400	17¢
13301 to 13350	18¢
13251 to 13300	19¢
13201 to 13250	20¢
13151 to 13200	21¢
13101 to 13150	22¢
13051 to 13100	23¢
13001 to 13050	24¢
12951 to 13000	25¢
12901 to 12950	26¢
12851 to 12900	27¢
12801 to 12850	28¢
12751 to 12800	29¢
12701 to 12750	30¢
12651 to 12700	31¢
12601 to 12650	32¢
12551 to 12600	33¢
12501 to 12550	34¢
12451 to 12500	35¢
12401 to 12450	36¢
12351 to 12400	37¢
12301 to 12350	38¢
12251 to 12300	39¢
12201 to 12250	40¢
12151 to 12200	41¢
12101 to 12150	42¢
12051 to 12100	43¢
12001 to 12050	44¢
12000 and below	45¢

COMMENT

Deduction out of all proportion for damage done. Correct for sulphur and volatile, which is wrong.

CONTRACT N

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, STONE & WEBSTER, MANAGEMENT ASSOCIATION

The following are the important clauses in the contract:

Net Price and Payment

(1) All coal accepted under the proposed contract will be paid for at a price per ton determined after the samples for each lot of coal have been analyzed. The prices named in the proposal for the coal specified will be corrected for variations in heat value, as shown by the analysis, and for variations in ash, volatile, sulphur and moisture, in accordance with the following provisions:

Price Correction for Heat Value

(2) The correction in price due to variation in B.t.u. of the coal above and below standard shall be in the proportion that the B.t.u., as shown by the analysis of the coal as delivered, bears to the B.t.u. in the standard as established by the bidder, and the price shall be increased or decreased in the same proportion, except that no premiums are to be paid or deductions are to be made from the contract price when the heat value of the coal a delivered is 150 B.t.u. or less, above or below the standard.

Price Correction for Ash

(3) The price will further be corrected for the percentage of ash, as shown by the analysis of coal as delivered in accordance with the following table:

1 per cent or less than 1 per cent variations from standard, premiums or deductions	$0.00
1½ per cent or less than 1½ per cent, but more than 1 per cent variation from standard, premiums or deductions	.01
2 per cent or less than 2 per cent, but more than 1½ per cent variations from standard, premiums or deductions	.04
2½ per cent or less than 2½ per cent, but more than 2 per cent variations from standard, premiums or deductions	.10
3 per cent or less than 3 per cent, but more than 2½ per cent variations from standard, premiums or deductions	.18
3½ per cent or less than 3½ per cent, but more than 3 per cent variations from standard, premiums or deductions	.32
4 per cent or less than 4 per cent, but more than 3½ per cent variations from standard, premiums or deductions	.50

For all variations from standard over four per cent, premiums and deductions are to be determined at the rate of twelve and one half cents per cent or fraction thereof of such variation.

Price Correction for Volatile Matter

(4) Price will be further corrected for the percentage of volatile, as shown by the analysis of coal as delivered in accordance with the following table:

	Per ton.
2 per cent or less than 2 per cent variations from standard, premiums or deductions	$0.00
3 per cent or less than 3 per cent, but more than 2 per cent variations from standard, premiums or deductions	.02
3½ per cent or less than 3½ per cent, but more than 3 per cent variations from standard, premiums or deductions	.04
4 per cent or less than 4 per cent, but more than 3½ per cent variations from standard, premiums or deductions	.08
4½ per cent or less than 4½ per cent, but more than 4 per cent variations from standard, premiums of deductions	.18
5 per cent or less than 5 per cent, but more than 4½ per cent variations from standard, premiums or deductions	.40

For all variations from the standard in excess of 5 per cent premiums and deductions are to be determined at the rate of 2 cts. per cent or fraction thereof of such variation.

Price Correction for Sulphur

(5) This price will be further corrected for the percentage of sulphur, as shown by the analysis of the coal as delivered in accordance with the following table:

	Per ton.
1 per cent or less than 1 per cent of sulphur in the coal deductions shall be	$0.00
1¼ per cent or less than 1¼ per cent, but more than 1 per cent deductions shall be	.06
1½ per cent or less than 1½ per cent, but more than 1¼ per cent deductions shall be	.14
1¾ per cent or less than 1¾ per cent, but more than 1½ per cent deductions shall be	.28
2 per cent or less than 2 per cent, but more than 1¾ per cent shall be	.60

All sulphur in excess of 2 per cent shall take deductions at the rate of 15 cents per one-fourth per cent or part thereof of the total sulphur in the coal.

Weight Correction for Moisture

(6) All moisture in excess of 3 per cent of the weight of the coal as delivered is to be deducted from that weight before price per ton is applied.

COMMENT

Deduction out of all proportion for damage done. Correct for sulphur and volatile, which is wrong.

CONTRACT O

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, BROOKLYN INTERBOROUGH RAPID TRANSIT CO., NEW YORK

Coal must be a good steam, coking, run-of-mine, bituminous coal free from all dirt and excessive dust, a dry sample of which will approximate the company's standard in heat value and analysis, as follows: Carbon, 71; volatile matter, 20; ash, 9; British thermal units, 14,100; sulphur, 1.50.

A small quantity of coal will be taken from each weighing hopper just before the hopper is dumped while the lighter is being unloaded. These quantities will be thrown into a receptacle provided for the purpose, and when the lighter is empty the contents of the receptacle will be thoroughly mixed, and a sample of this mixture will be taken for chemical analysis. This average sample of coal will be labeled and held for one week after the unloading of the lighter. The sample taken from the mixture for test will be analyzed as soon as possible after being taken. No other sample will be recognized.

Tests of sample taken from average sample will be made by the company's chemist under the supervision of the superintendent. Should the contractor question the results of the company's test (a copy of which will be mailed to him), the company will, if requested by the contractor within three days after copy of test has been mailed to him, forward sufficient quantity of the average sample taken from each weighing hopper to any laboratory in the city of New Yorkwhich may be agreed upon by the superintendent and the contractor, and have said sample analyzed by it, and the results obtained from this second test will be considered as final and conclusive. In case the disputed values, as obtained in the company's test, shall be found by the second test to be 2 per cent or less in error, then the cost of said second test shall be borne by the contractor; but if the disputed values shall be found to be more than 2 per cent in error, then the cost of said second test shall be borne by the company.

Should there be no question raised by the contractor within the three days specified, as to the values of the first analysis, the average sample of coal will be destroyed at the end of seven days from date of discharge of coal from lighter. Should a second test be made of coal taken from any lighter as herein provided, then any penalties to be made as set forth in paragraph under "Penalties" will be based on the results as obtained from the second test.

The price to be paid by the company per ton per lighter of coal will be based on a table of heat values for excess or deficiency of its standard, but subject to deductions as given in the section under "Penalized coal," including excess of ash, volatile matter, sulphur, or dust, or less than the minimum amount required to be contained in any lighter, for coal which shows results less than the company's standard.

Premiums or deductions are based on a rate of 1 cent per ton for a variation of 50 British thermal units per pound of coal, as indicated in a table a few items of which are given below:

Table for B.t.u. Values.

For coal in any lighter which is found by test to contain, per pound of dry coal, from—

15,501 and above	28 cts. per ton above stated
15,101 to 15,150, both inclusive	20 cts. per ton above stated
14,601 to 14,650, both inclusive	10 cts. per ton above stated
14,101 to 14,150, both inclusive	Standard
13,601 to 13,650, both inclusive	10 cts. per ton below stated
13,101 to 13,150, both inclusive	20 cts. per ton below stated
12,101 to 12,150, both inclusive	40 cts. per ton below stated

No lighter of coal will be accepted which, by trial, in the judgment of the superintendent, contains an excessive amount of dry coal dust. The decision of the superintendent will be final in this respect. Coal taken from such lighter for trial will be subject to the special deduction set forth under "Penalized coal," but paid for in all other respects as herein provided.

Coal which is shown by analysis to contain less than 20 per cent of volatile matter, 9 per cent of ash, or 1.50 per cent of sulphur, will be accepted without a deduction from the bidder's price, plus or minus an amount for excess of deficiency of British thermal unit value, as herein provided. Where the analysis gives amounts for any or all elements in excess of these quantities, deductions will be made from the bidder's price in accordance with the tables of values of volatile matter, ash, and sulphur below given, plus or minus the amount for excess or deficiency of the standard British thermal unit value, in addition to any other deductions which may be made as herein provided.

Table of Deductions for Volatile Matter.

For coal in any lighter which is found by test to contain, per pound of dry coal:

Over 20 per cent and less than 21 per cent	2 cents per ton
Over 22.5 per cent and less than 23 per cent	12 cents per ton
24 per cent and over	18 cents per ton

This table is made for a difference of each one-half of 1 per cent and the deductions are at the rate of four cents for each 1 per cent of volatile matter.

Table of Deductions for Ash

For coal in any lighter which is found by test to contain, per pound of dry coal:

Over 9 per cent and less than 9.5 per cent	2 cents per ton
Over 11.5 per cent and less than 12	12 cents per ton
5.13 per cent and over	23 cents per ton

This table is made for each difference of one-half of one per cent and at the rate of four cents for each 1 per cent increase in the ash.

Table of Deductions for Sulphur

For coal in any lighter which is found by test to contain, per pound of dry coal:

Over 1.50 per cent and less than 1.75 per cent	6 cts. per ton
Over 2 per cent and less than 2.25 per cent	10 cts. per ton
2.50 and over	20 cts. per ton

This table is made out for each difference of one-fourth of 1 per cent and at a diminishing rate.

Should any lighter of coal delivered at the company's docks contain less than 700 tons, a deduction of 7 cents per ton will be made from the price as determined by the British thermal unit value and analysis, in addition to any other penalty provided for herein. Should any lighter of coal delivered at the company's docks be rejected by the superintendent on account of excessive amount of coal dust, then a deduction of 25 cents per ton will be made from the price as determined by the British thermal unit value and analysis, for the coal taken from said lighter, in addition to any other penalty which may be made as herein provided. Should any lighter of coal be delivered in other than self-trimming lighters as herein provided, a deduction of 7 cents per ton will be made from the price as determined by the British thermal unit value and analysis, exclusive of any other penalty which may be made as herein provided.

The contractor's bill of lading will be checked by the company's scales. Should there be a deficiency of 1 per cent or more between the bill of lading and the company's weights, then the company's weights will be taken as correct.

COMMENT

Deduction out of all proportion for damage done. Correct for sulphur and volatile, which is wrong.

CONTRACT P

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, LARGE BALTIMORE FIRM

The following specification is used by a few firms in Baltimore, Md.

SPECIFICATIONS AND INFORMATION CONCERNING SUPPLY OF COAL FOR...... . ...

Caution

Bidders are directed to familiarize themselves with the storage facilities and local conditions, affecting the deliveries of coal, existing at the power house.

Method of Determining Quantity and Quality.

Weights are subject to check either by measurement or by company scales. Any deficiency will be deducted from and any excess added to the bill.

Sampling will be done by a representative of the company and contractor may have a representative present.

Samples will be taken from each delivery and kept in hermetically sealed jars.

Detail of Specifications

Coal will be semi-bituminous and run-of-mine. It shall be dry, well picked, and free from excessive amounts of slate, pyrites, and dirt of any kind and shall have the following composition: Moisture, not over 1 per cent; volatile carbon, not over 20 per cent; ash, not over 7 per cent; sulphur, not over 1 per cent.

ADJUSTMENTS.

Additions

If the coal has less than 1 per cent moisture the deficit per cent less than 1 per cent will be added to the bill. If the coal has less than 20 per cent volatile carbon, the deficit per cent less than 20 per cent will be multiplied by 2 and added to the bill. If the coal has less than 7 per cent ash, the deficit per cent less than 7 per cent will be multiplied by 3 and added to the bill.

Deductions

If the coal contains more than 1 per cent moisture, the excess per cent above 1 per cent will be deducted from the bill. If the coal contains more than 20 per cent volatile carbon, the excess per cent above 20 per cent will be multiplied by 2 and deducted from the bill. If the coal contains more than 3 per cent ash, the excess per cent above 7 per cent will be multiplied by 3 and deducted from the bill.

COMMENT

Deductions not sufficient to equal loss sustained.

CONTRACT Q

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, CITY OF NORFOLK

Guaranteed Quality

The contractor shall guarantee that the coal supplied shall be equivalent to the coal supplied to the Water Department by the Water Front Coal Company, from July 15, 1908, to March 14, 1909, under the regular conditions of operation. This guarantee to apply to the pounds of water evaporated per pound of coal only. A copy of the results above referred to is given below, these results being taken from the records of the pumping station log book, which book shall also be used to obtain the results for the coal supplied under this specification:

Water pumped, 2-million pump	1,087,500 gals.
Water pumped, Gaskill pump	39,903,600 gals.
Water pumped, 5-million pump	78,374,750 gals.
Water pumped, 10-million pump	1,444,282,400 gals.
	1,563,648,950 gals.
Total feed water evaporated from 170 deg	41,562,688 lbs.
Total coal burned	3,852,500 lbs.
Total ashes obtained	532,920 lbs.
Per cent of ash	13.83 p. c.
Total water evaporated per pound of coal	10.79
Total water pumped per pound	405.88 gals.

Inspection

The quality of coal shall be subject to the inspection of the engineer in charge of the Water Department, and if in his opinion such coal shall not be of the quality specified as regards impurities, cleanliness or amounts of lumps, the acceptance or rejection of such coals shall be decided by arbitration, the Water Department to choose one arbitrator, the contractor, one arbitrator, and these two to choose a third, and the decision of these shall be final and binding on both contractors and owner.

Penalty

Payments for coal will be made monthly as coal is delivered; the payment to be based on the net weight furnished by some recognized weighing bureau located in Norfolk or Berkley or as otherwise agreed upon.

COMMENT

Do not believe in evaporative tests as a basis of settling coal bills.

CONTRACT R

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, CIVIL ENGINEER, BOSTON

(1) Coal shall be of steaming quality, bituminous or semi-bituminous run-of-mine, and as free from deleterious and objectionable matter as consistent with the best mining and transportation practice.

(2) Payment shall be made on the weight of coal as delivered to the consumer.

(3) Representative samples selected from the coal as delivered to the consumer, shall, on laboratory test, not exceed the following limits of the substances named:

Moisture, per cent	1
Volatile matter, per cent	22
Sulphur, per cent	1
Ash and solid matter, per cent	7

(4) Bidders shall state in their proposals the least calorific value of the coal they propose to furnish, when dried, in British thermal units per pound of coal. The calorific value named in the accepted proposal shall form part of the contract, and tests will be made for same on dried coal from representative samples of the coal as delivered. Coal falling short in calorific value of the standard established by the accepted bid shall be reduced proportionately in price.

(5) For each one whole per cent of moisture on laboratory test in excess of the limit named, there shall be deducted one cent per ton from the contract price of the coal.

(6) For each one whole per cent of ash and solid matter on laboratory test in excess of the limit named, there shall be deducted one cent per ton from the contract price of the coal.

(7) For each whole half per cent of sulphur on laboratory test in excess of the limit named there shall be deducted one cent per ton from the contract price of the coal.

(8) For each one whole per cent resulting from the addition of the excess of moisture, sulphur, ash and solid matter, or any two of them, when below the deduction limits named for each separately, on laboratory test, there shall be deducted one cent per ton from the contract price of the coal.

(9) Tests for calorific value shall be made with a bomb calorimeter, and all laboratory tests in accordance with the latest approved methods of the American Chemical Society.

(10) The contractor, or his authorized representatives, may have the privilege of witnessing the weighing, sampling and analysis of coal, provided that no undue delay is caused thereby, or the user may have the same verified by a competent and responsible person; but in any event the weighing, sampling and analysis made upon the delivery of coal shall be final.

(11) Failure of the coal to comply with the specified requirements and original limitations shall be sufficient cause for rejection or cancellation of the contract.

COMMENT

Deductions erratic. Not founded on sound basis.

CONTRACT S

EXTRACTS FROM CONTRACT AND SPECIFICATIONS, BITUMINOUS COAL, MUNICIPAL TRACTION COMPANY, CLEVELAND

Quality.

The coal to be clean, fresh-mined Ohio bituminous slack, dry burning and free from impurities, such as slate, stone and dust, and equal in all respects to the following standard:—British thermal units, 12,500; Ash, 15 per cent; and Sulphur, 3.5 per cent, per pound of dry coal; *i. e.*, coal heated for one hour at 100 degrees C.; and to be pulverized to pass through a 100 mesh sieve.

Basis Upon Which Payments are to be Made

Each day's consignment of coal furnished by the contractor during the continuation of this contract shall be sampled by the Superintendent or his authorized agent, and analyzed to determine its heating value, and the price to be paid by the company, per ton, per car of coal will be based on a table of heat values for excess or deficiency of the standard herein contained, but subject to further deductions for ash and sulphur.

A small quantity of coal will be taken from at least five different places in each car received, by driving into the coal a 5-foot ram, before the car is unloaded. These quantities thus received from each car of coal of the day's consignment will be thrown into a receptacle provided for this purpose, and thoroughly mixed, and a properly selected sample of this mixture will be taken for chemical analysis. One-half of this sample of the average mixture will be labeled and held at the company's laboratory for a period of two weeks after the unloading of the cars. The other half of the sample taken from the average mixture will be analyzed as soon as possible after being taken. No other sample will be recognized.

Tests of the sample taken from the average mixture will be made by the company's chemist under the supervision of the Superintendent. Should the contractor question the results of the company's test (a copy of which will be mailed him), the company will, if requested, within three days after copy of test has been mailed him, forward the other half of the sample held for this purpose, to any laboratory in the City of Cleveland which may be agreed upon by the Superintendent and the Contractor, and have said sample analyzed by it, and the results obtained from this second test shall be considered as final and conclusive. In case the disputed values, as obtained in the company's test, shall be found by the second test to be 2 per cent or less in error then the cost of said second test shall be borne by the Contractor; but if the disputed values shall be found to be more than 2 per cent, then the cost of said second test is to be borne by the company.

Should there be no question raised by the Contractor within the three days specified, as to the values of the company's analysis, the second sample of coal will be destroyed at the end of two weeks from the date of unloading of the cars from which it was taken. Should a second test be made of the sample of the average mixture as herein provided, then any penalties to be made will be based on the results as obtained from the second test.

Table for B.t.u. Values

For coal in any car which is found by analysis to contain per pound of dry coal—

13,975 and above	35¢. per ton above standard
13,850 to 13,974, inclusive	35c. per ton above standard
13,725 to 13,849, inclusive	30¢. per ton above standard
13,600 to 13,724, inclusive	25¢ per ton above standard
13,475 to 13,599, inclusive	21¢ per ton above standard
13,350 to 13,474, inclusive	17¢ per ton above standard
13,225 to 13,349, inclusive	13¢ per ton above standard
13,100 to 13,224, inclusive	10¢ per ton above standard
12,975 to 13,099, inclusive	7¢ per ton above standard
12,850 to 12,974, inclusive	5¢ per ton above standard
12,725 to 12,849, inclusive	3¢ per ton above standard
12,600 to 12,724, inclusive	1.5¢ per ton above standard
12,475 to 12,599, inclusive	standard
12,350 to 12,474, inclusive	1.5¢ per ton below standard
12,225 to 12,349, inclusive	3¢ per ton below standard
12,100 to 12,224, inclusive	5¢ per ton below standard
11,975 to 12,099, inclusive	7¢ per ton below standard
11,850 to 11,974, inclusive	10¢ per ton below standard
11,725 to 11,849, inclusive	13¢ per ton below standard
11,600 to 11,724, inclusive	17¢ per ton below standard
11,475 to 11,599, inclusive	21¢ per ton below standard
11,350 to 11,474, inclusive	25¢ per ton below standard
11,225 to 11,349, inclusive	30¢ per ton below standard
11,100 to 11,224, inclusive	35¢ per ton below standard
10,975 to 11,099, inclusive	40¢ per ton below standard
10,850 to 10,874, inclusive	45¢ per ton below standard
10,725 to 10,849, inclusive	50¢ per ton below standard
10,600 to 10,724, inclusive	55¢ per ton below standard
10,475 to 10,599, inclusive	60¢ per ton below standard
10,350 to 10,474, inclusive	65¢ per ton below value
10,225 to 10,349, inclusive	70¢ per ton below standard
10,100 to 10,224, inclusive	75¢ per ton below standard
9,975 to 10,099, inclusive	80¢ per ton below standard

9,774 and below an additional ten (10) cents per ton per car will be deducted for each one (1) per cent variation below standard.

Penalties for Excess Ash and Sulphur

Coal which is shown by analysis to contain less than 15.0 per cent of ash and 3.5 per cent of sulphur will be accepted without a deduction from the contract price, plus or minus an amount of excess or deficiency of British thermal units value, as hereinabove provided. Where the analysis gives amounts for any and all elements in excess of these quantities deductions will be made from the contract price in accordance with penalties provided herein, for value of ash and sulphur below given, plus or minus the amount for excess or deficiency of the standard British thermal unit value.

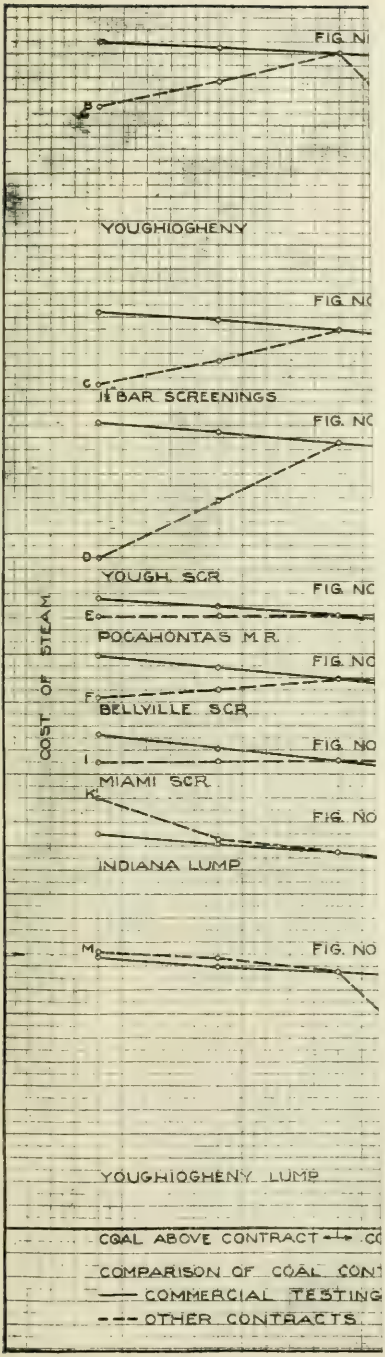
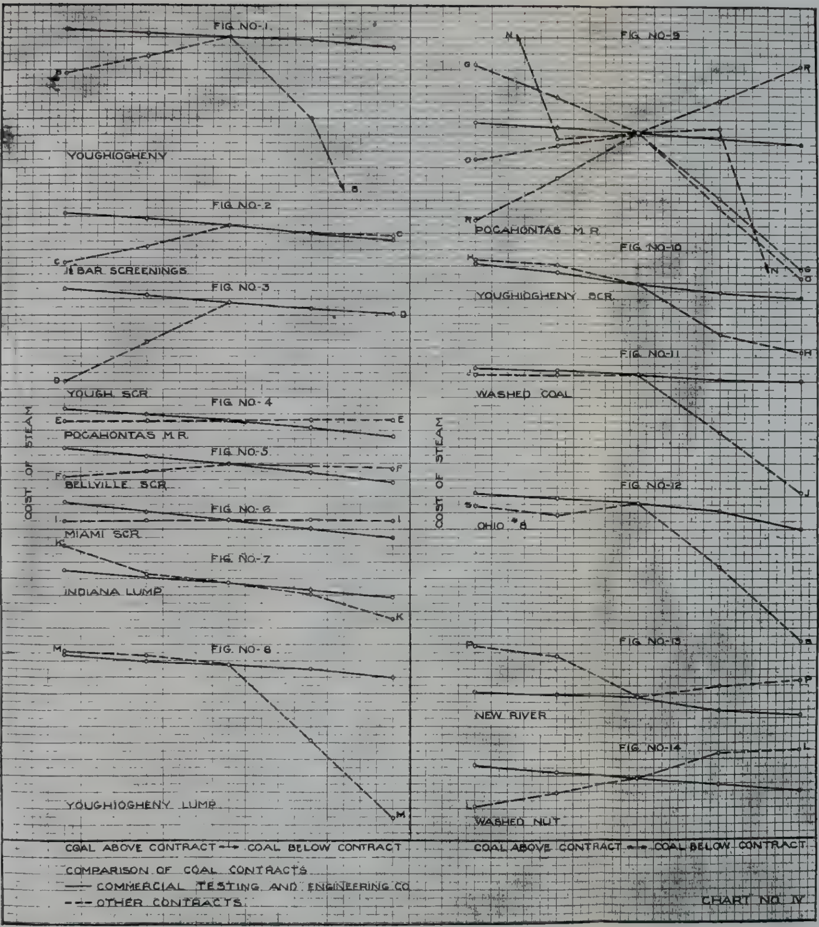


FIG. N
B
YOUGHIOGHENY
FIG. NO
C
1½ BAR SCREENINGS
FIG. NO
D
YOUGH. SCR.
FIG. NO
E
POCAHONTAS M.R.
FIG. NO
F
BELLVILLE SCR.
FIG. NO
I
MIAMI SCR.
K
FIG. NO
INDIANA LUMP
M
FIG. NO
YOUGHIOGHENY LUMP
COST OF STEAM
COAL ABOVE CONTRACT ← → CO
COMPARISON OF COAL CON
—— COMMERCIAL TESTING
- - - OTHER CONTRACTS.



COMPARISON OF COAL CONTRACTS

CHART NO IV

Table for Deductions of Ash

0.0 to 15 p. c., inclusive	Standard
15.1 to 16 p. c., inclusive	3¢ below standard, per ton
16.1 to 17 p. c., inclusive	6¢ below standard, per ton
17.1 to 18 p. c., inclusive	9¢ below standard, per ton
18.1 to 19 p. c., inclusive	12¢ below standard, per ton
19.1 to 20 p. c., inclusive	15.5¢ below standard, per ton
20.1 to 21 p. c., inclusive	19¢ below standard, per ton
21.1 to 22 p. c., inclusive	22¢ below standard, per ton
22.1 to 23 p. c., inclusive	25¢ below standard, per ton
23.1 to 24 p. c., inclusive	28¢ below standard, per ton
24.1 to 25 p. c., inclusive	31¢ below standard, per ton
25.1 to 26 p. c., inclusive	34¢ below standard, per ton
26.1 to 27 p. c., inclusive	37¢ below standard, per ton
27.1 to 28 p. c., inclusive	40¢ below standard, per ton
28.1 to 29 p. c., inclusive	43¢ below standard, per ton
29.1 to 30 p. c., inclusive	46.5¢ below standard, per ton

Table for Deductions of Sulphur

3.5 to 3.9 p. c., inclusive	Standard
4.0 to 4.4 p. c., inclusive	2¢ per ton below standard
4.5 to 4.9 p. c., inclusive	5¢ per ton below standard
5.0 to 5.4 p. c., inclusive	7¢ per ton below standard
5.5 to 5.9 p. c., inclusive	9¢ per ton below standard
6.0 to 6.4 p. c., inclusive	12¢ per ton below standard
6.5 to 6.9 p. c., inclusive	14¢ per ton below standard
7.0 to 7.4 p. c., inclusive	16¢ per ton below standard
7.5 to 7.9 p. c., inclusive	19¢ per ton below standard
8.0 to 8.4 p. c., inclusive	21¢ per ton below standard
8.5 to 8.9 p. c., inclusive	23¢ per ton below standard
9.0 to 9.4 p. c., inclusive	26¢ per ton below standard
9.5 to 9.9 p. c., inclusive	28¢ per ton below standard
10.0 to 10.4 p. c., inclusive	30¢ per ton below standard

COMMENT

Deductions too great. Should not correct for sulphur.

Now that we have all of the various forms of contracts before us, let us see how they conform to the basic principle suggested.

In order to make this comparison I have assumed a constant boiler and furnace efficiency of 60 per cent. While this is not correct I do not at this time wish to state how much I think the efficiency would change with the increase in ash. Chart III, I submit, shows a contract coal analyzing as follows:

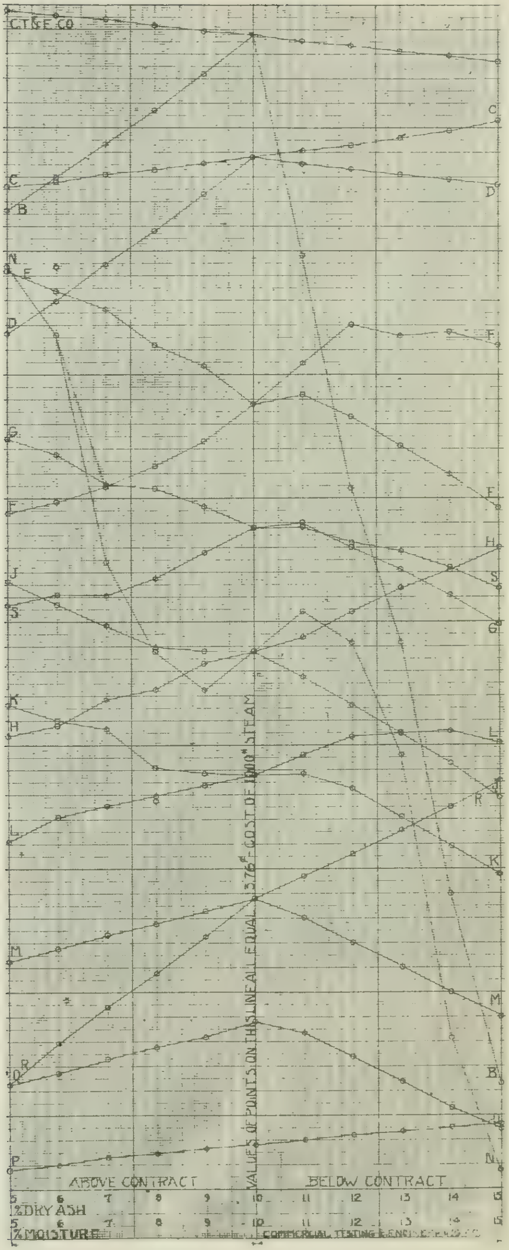


DIAGRAM INDICATING
STEAM COSTS FOR VARYING QUALITIES OF COAL
UNDER
VARIOUS CONTRACT FORMS
ANALYSES ON SINGLE COAL USED AS BASIS

CHART II

Moisture	10 p. c.
Dry ash	10 p. c.
B.t.u. dry	13,000
Contract price	$2.00
Net B.t.u., one cent	114,140

Coal as Delivered.

Moisture p. c.	B.t.u. Dry	Dry Ash p. c.
5	13750	5
6	13600	6
7	13450	7
8	13300	8
9	13150	9
10	13000	10
11	12850	11
12	12700	12
13	12550	13
14	11400	14
15	12250	15

You will note the fluctuations from this contract grade were at the rate of 1 per cent ash and 1 per cent moisture for each determination. This of course altered the B.t.u. each time. Reading from left to right on the chart, you will note the fluctuations in the cost of producing steam under each of these contracts, this of course being based upon 60 per cent efficiency being obtained. The contract which I submit is figured on the basis of a corrected efficiency. This would make the curve of our contract absolutely straight. The letter at the end of each curve refers to the contract index. I have plotted these results in this manner in order to show that the contracts as I have obtained them are not suitable for general use. Chart IV shows the results of the various contracts compared with our contract upon the kind of coal that the contracts were intended to be used upon. All of the contracts make a better showing than in Chart III. At thesa me time, the contract which I submit works out satisfactorily in each case and therefore is, I believe, worthy of universal adoption.

There is one point however, upon which I wish to caution everyone who contemplates using a heat value contract. No matter how carefully the same may be drawn or how correct it may be in adjusting fluctuations in quality, if the contract data upon which it is based is incorrect, it will work to the detriment of either the consumer, who will pay a high price for his coal, or the coal contractor, who will sell his coal at a much lower price than he intended.

INDEX TO CHARTS

A City of Brooklyn
B City of Pittsburg
C Saginaw firm
D City of Minneapolis
E City of Boston
F City of St. Louis
G Marshall & Co., coal dealers
H City of Cleveland
I City of Chicago
J Birmingham firm
K American Can Co.
L United States Government, Treasury Department
M American Bridge Works
N Stone & Webster Management Association
O Interborough Rapid Transit Co.
P Baltimore firm
Q City of Norfolk
R Civil Engineer, Boston
S Municipal Traction Co., Cleveland.

The following are the analyses used in Chart IV:

Fig. 1

Youghiogheny Lump

	MOISTURE	ASH	DRY B.T.U.	PRICE
Contract	5.0	6.0	14043	$1.75
	5.0	7.0	13865	
	5.0	8.0	13685	
	5.0	9.0	13558	
	5.0	11.0	13148	

FIG. 2

1½-in. Bar Screenings

	MOISTURE	ASH	DRY B.T.U.	PRICE
Contract	7.5	11.0	12640	$1.20
	7.5	13.0	12320	
	7.5	15.0	12000	
	7.5	17.0	11680	
	7.5	19.0	11360	

FIG. 3

Youghiogheny Screenings

	MOISTURE	ASH	DRY B.T.U.	PRICE
Contract	6.0	8.0	13680	$3.00
	6.0	10.0	13340	
	6.0	12.0	13000	
	6.0	14.0	12660	
	6.0	16.0	12320	

FIG. 4

Pocahontas Mine Run

	MOISTURE	ASH	DRY B.T.U.	PRICE
Contract	4.0	1.0	15643	$4.75
	4.0	3.0	15303	
	4.0	5.0	14963	
	4.0	7.0	14623	
	4.0	9.0	14283	

FIG. 5

Belleville Screenings

	MOISTURE	ASH	DRY B.T.U.	PRICE
Contract	14.0	16.0	11860	$0.90
	14.0	18.0	11560	
	14.0	20.0	11260	
	14.0	22.0	10960	
	14.0	24.0	10660	

Fig. 6

Miami Screenings

	MOISTURE	ASH	DRY B.T.U.	PRICE
	12.8	13.0	12470	
	12.8	15.0	12158	
Contract	12.8	17.0	11838	$2.00
	12.8	19.0	11518	
	12.8	21.0	11190	

Fig. 7

Indiana Lump

	MOISTURE	ASH	DRY B.T.U.	PRICE
	6.0	8.0	13580	
	7.0	10.0	13240	
Contract	8.0	12.0	12900	$1.95
	9.0	14.0	12560	
	10.0	16.0	12220	

Fig. 8

Youghiogheny Lump

	VOL. COMB.	SUL.	MOISTURE	ASH	DRY B.T.U.	PRICE
	32.0	1.00	5.0	6.0	14043	
	33.0	1.20	5.0	7.0	13865	
Contract	34.0	1.50	5.0	8.0	13685	$2.00
	35.0	1.75	5.0	9.0	13558	
	36.0	2.15	5.0	11.0	13148	

FIG. 9

Pocahontas Lump

	VOL. COMB.	SUL.	MOISTURE	ASH	DRY B.T.U.	PRICE
	18.0	1.00	4.0	4.5	14880	
	19.0	1.25	4.0	6.5	14540	
(Marshall & Co.) Contract. .	20.0	1.50	4.0	8.5	14200	$4.00
(Stone & Webster).	21.0	1.80	4.0	10.5	13860	
(Civil Eng. Boston).	22.0	2.50	4.0	12.5	13520	
	18.0	.60	4.0	4.5	14880	
Interborough R. T. Co.	19.0	.80	4.0	6.5	14540	
Contract.	20.0	1.50	4.0	8.5	14200	4.00
	21.0	1.70	4.0	10.5	13860	
	22.0	2.10	4.0	12.5	13520	

FIG. 10

Youghiogheny Screenings

	MOISTURE	ASH	DRY B.T.U.	PRICE
	6.0	8.0	13680	
	6.0	10.0	13340	
Contract.	6.0	12.0	13000	$1.50
	6.0	14.0	12660	
	6.0	16.0	12320	

FIG. 11

Washed Coal

	SUL.	MOISTURE	ASH	DRY B.T.U.	PRICE
	.51	.85	10.1	13451	
	.60	.85	11.2	13264	
Contract.	.80	.85	12.0	13111	$2.50
	1.10	.85	13.0	12858	
	1.50	.85	14.1	12671	

Fig. 12

	SUL.	MOISTURE	ASH	DRY B.T.U.	PRICE
		10.0	12.0	13150	
		10.0	13.0	12825	
Contract........................	3.5	10.0	15.0	12500	$2.00
	4.1	10.0	17.2	12145	
	4.6	10.0	19.2	11815	

Fig. 13

New River

	VOL. COMB.	MOISTURE	ASH	DRY B.T.U.	PRICE
	16.0	.75	2.0	15360	
	17.0	1.0	3.0	15180	
Contract........................	18.0	2.0	4.0	15000	$2.00
	19.0	3.0	6.0	14640	
	20.0	4.0	8.0	14280	

Fig. 14

Washed Nut

	MOISTURE	ASH	DRY B.T.U.	PRICE
	6.0	6.0	13600	
	8.0	8.0	13300	
Contract........................	10.0	10.0	13000	$2.00
	12.0	12.0	12700	
	14.0	14.0	12400	

All of the above results are based upon the assumption that the sample taking and laboratory work have been done correctly. We know it is wrong for the coal contractor to rob the consumer by the delivery of coal other than that contracted for. At the same time we will not mend matters if we proceed to rob the coal contractor by taking unfair samples and improperly analyzing the same. A short outline of the methods used in my laboratory where many thousands of samples have been analyzed and not a single law suit generated will be of interest.

The sample taking in all cases is done by men who have been carefully instructed and who are under the surveillance of an inspector. Their instructions are as follows:

INSTRUCTIONS FOR COMMERCIAL SAMPLING OF COAL

METHODS OF COLLECTING SAMPLES

Screenings or Small Coal From Loaded Cars.

A trench should be made across the middle of the car; also a trench four feet from each end of the car. These trenches should be about two feet in width and dug one foot below the top of the car sides. From each of these trenches five samples, of five to seven pounds weight, should be taken at uniform intervals, one from the center, and two each from both sides of the center. The total weight from the three trenches should be about 100 pounds.

Screenings or Small Coal from Partially Unloaded Cars

One or more trenches should be made across that part of the car not broken into. The remainder of the car should be sampled in the same manner as is coal in the bunkers.

Sampling from Bunkers

(Any size coal excepting Lump or Run of Mine)

The surface of the pile should be scraped off in a number of places, so as to insure the removal of any foreign matter that may have been thrown on the coal since unloading. Starting at the bottom of the pile, a little coal should be taken with a shovel from these different locations from top to bottom of the slanting surface. This should be done in a number of places. The center of the pile should also be dug into and some coal obtained therefrom. The large pieces of coal, of course, will roll to the bottom of the pile. For this reason care must be exercised to insure a proper proportion of large and small sizes.

Lump Coal

In sampling lump coal, a selection should be made of representative lumps, from the surface of the pile or car, to insure that a proper proportion of large and small pieces are taken.

These lumps should be broken up, and a piece about egg size retained from each. For such sample at least about 200 pounds should be collected.

Run of Mine Coal

In sampling mine run coal a proper proportion of large and fine sizes must be taken, so that the sample will be at least 200 pounds in weight.

PREPARATION OF SAMPLE AFTER ITS COLLECTION

For preparation of the sample there may be employed a dry hard surface, preferably a concrete or stone floor or a large iron plate, that should be clean, upon which the coal collected should be placed. All large pieces of the coal should then be broken and reduced to a size one-half inch in diameter. After this the coal should be kept as nearly as possible in a circular shape. After a thorough mixing, the coal should be carefully divided into equal quarters with a shovel, and either of the two opposite quarters removed and thrown into the coal bin or elsewhere. The process of breaking up, mixing and quartering should be continued until the large pieces of coal are as small as grains of wheat. When it has reached this stage, the sample should again be mixed thoroughly together and again quartered, and should the two remaining quarters be more than can be contained in the sample can or glass jar prepared to receive the sample, the mixing and quartering should be continued until sufficiently reduced to be all contained in the can or jar.

All of this work should, of course, be conducted with as much rapidity as possible, so that the loss of moisture from the sample during the process of preparation will be at a minimum.

The Commercial Testing and Engineering Company will be glad to furnish, free of charge, air-tight, friction-top, tin cans as containers for samples.

The cans we use are of the friction top type holding one pound. Upon each can is a label which the sample taker makes out and signs his name to. This label contains the name of the plant from which the sample is taken, the size of the coal, the dealer, the date and the car number. These samples are delivered to the laboratory and kept in a cool, dry place until the time arrives for compositing the same. On some of the larger plants we analyze once a week and the smaller ones twice in two weeks. When the composite sample is made up all of the cans which enter into the composite are dumped upon the bucking board and a sample of 5 grams weighed out, placed on a clean watch glass, dried 1½ hours, cooled in a desiccator and weighed. This makes the moisture determination. We use a double jacketed hot-air oven, the jacket being filled with hot air. The composite sample upon the bucking board is then quartered down and ground to 60 mesh, one half of the ground sample being placed in an envelope for future reference, the balance being placed in a glass bottle tightly corked with rubber cork. You will note we make our moisture determination upon the coal before the same is ground in order to prevent loss of moisture and we dry it one-half hour longer than is customary.

Our sulphur determinations are made by the fusion method, using peroxide sodium.

Our ash determinations are made upon one-gram samples of the finely ground oven-dried coal.

Our calorific determinations are made in a platinum lined Mahler bomb calorimeter, we finding the work of this instrument to be more nearly accurate than any other in use. Before any analysis upon which the delivered value is determined leaves the office, it is checked by an expert who is familiar with the analysis of the various coals which pass under our inspection. The calorific determinaitons checked against a table showing the B.t.u. for each per cent of ash. The analysis checker upon receiving the laboratory report turns to the table representing the kind of coal which we are supposed to receive If the Mahler determination checks with the table at the ash given in the report the analysis is approved. If the same does not check, it is apparent that the coal company has substituted other coal. The sample is sent back to the laboratory for a re-run. If the second determination checks with the first, we then examine the different tables to ascertain with which table it will check. In this way we are many times able to identify the kind of coal being delivered in place of contract grade. The tables I refer to are made in the following manner: The sample of nut and slack is taken, containing about 25 pounds. This is not selected in any particular manner and is not crushed down at all. Same is placed upon the bucking board, where we pick out by hand several pounds of the best coal nut size. This sample you can see would be very low in ash. It is crushed down and ground so that we have about 25 grams left. We then pick a second sample in such a way that it will have the maximum amount of ash possible, being careful to see that this sample has all the ash constituents present in the proper natural proportion. This can be done by the proper crushing and mixing and is necessary for the reason that there is often present pieces of both roof and bottom which vary widely in their character. We then have two samples of coal, one of which is the very best coal that could possibly be gotten from the mine in a commercial way, the other representing the same coal but very high in ash. These two samples are then ground to pass a 100-mesh sieve the ash determined on each sample. From the ash of these two samples there are calculated four more samples to make a series having different per cent of ash increasing in regular order. These samples are made from mixtures of the high and low ash sample. For instance, if we find our low ash to be 5 per cent and the high ash 20 per cent, four mixtures are made of these two coals which would have respectively 8, 11, 14 and 17 per cent of ash. The sulphur ash and calorific determination is made upon each of these samples. The ash and B.t.u. are plotted on cross-section paper and we find that every time we can draw a straight line through a majority of the points plotted, showing that as the ash increases the B.t.u. decreases a certain amount for each per cent of ash.

We have now completed tables on over 175 different mines; some of these tables which were made two or three years ago I have checked several times by making new tables upon the same mine. In each case I find that the curve is the same as originally plotted, proving conclusively that the B.t.u. per pound of true combustible does not change.

The advantage derived by municipal corporations purchasing their coal upon heat value contract is great, as it prevents the interference of politics and eliminates all opportunity for grafting and other irregularities which might produce a scandal. The following are prominent among those who purchase their coal by heat value contract. United States Government Treasury Department, City of Minneapolis Water Department, Cook County Public Institutions, Illinois, South Park Commissioners, Chicago, Lincoln Park Commissioners, Chicago, Illinois State Penitentiary, Joliet, Illinois Insane Hospital, Kankakee, Kentucky State Board of Control, Charitable Institution, Frankfort, Ky. I have been informed that many others would have liked to purchase their coal upon this basis, but had had trouble in securing bids. I find that coal dealers will accept a fair contract as a rule. Many will not, however, on account of comments they have heard by other coal dealers who have tried the heat value method and lost money. The coal companies as a rule are not well informed upon this subject and are willing once to take a gambler's chance. If they lose on it they are opposed to everything of the sort in the future. For that reason, if for no other, we should try and make our contracts fair and equitable. Otherwise the coal operators will unite to refuse all contracts based upon guarantees.

DISCUSSION

Mr. Edward H. Taylor: I had a B.t.u. contract at the Illinois State Penitentiary. We went there to get the chief engineer interested. He said he didn't want to go into it until he had called in the coal contractor and had a little talk with him. He sent for the coal contractor, who was an old gentleman who had been in the coal business for some forty years, a very fine gentleman and very highly respected. He went to the Board meeting. The President had said to me that he was not very well versed and he wanted me to prepare some questions for him to ask. I did so. So when the coal dealer walked in the President picked up the paper and said to him: "How much moisture has your coal got?" The coal man replied, "It has got some moisture, it is washed coal, you know; it has got moisture all right." "What per cent of ash has your coal got?" "It has got quite a little ash; we get as much ash as we can, but it has some ash all right." By this time the old fellow had begun to fidget around in his chair and he was getting sort of uneasy. The President looked at his paper again, found his place, and he said: "How much sulphur has your coal got?" "Oh, it has got some sulphur, sulphur enough to make it burn all right." By that time the old man began to get very uneasy, he got up out of his chair and commenced walking up and down the room.

He said: "What's the matter with my coal? Isn't it all right? I have been delivering coal for eighteen years, and never heard a word of complaint yet. Isn't it all right?" "Yes, but we are talking about changing our mode of doing business and we just want to know some things. How many B.t.u.'s has your coal got?" The old man jumped up, walked over to the table, and says: "Not a dammed one!"

CHEMICAL DATA AS RELATED TO THE POWER PLANT

S. W. PARR

In all water supply plants where steam is employed as the motive force, undoubtedly the greatest single item of operating expense resides in the fuel charges. Much activity in recent years is in evidence looking to the more careful scrutiny of the coal bin and all that pertains to the contents thereof, from its initial purchase to the final disposal of the products in the form of ash, gas, and smoke. It is the purpose of this paper to discuss briefly the function that chemistry may perform in this inspectional program.

If we were to classify the uses to which coal data of a chemical sort are to be put, they would fall under three general divisions:

1. Analytical results which are obtained by operators or sellers of coal for advertising or sale purposes.

2. Chemical facts which serve as the medium for regulating the conditions of purchase and sale, that is, as a contract basis.

3. Chemical data which may serve as the ultimate and fundamental basis for estimating (*a*) relative adaptability of different grades or forms of the fuel employed; (*b*) efficiencies of equipment; and (*c*) unit cost for work accomplished.

If we discuss these divisions in their natural order, we shall take up first the use of chemical data for informational or advertising purposes. Under this heading it is perhaps not too much to say that the greatest abuses known to chemistry are perpetrated. I take as an illustration the letter-head of a coal operator which sets forth the composition of his coal. In the first place the figures have attained their majority as to years and may perhaps be entitled to venerable respect on account of age, having been used in the above-indicated manner for well-nigh a quarter of a century. A face sample from this same mine taken within the current year shows moisture 300 per cent more in amount than is indicated in the letter-head, and ash 200 per cent more, with corresponding reductions in the percentages of volatile matter and fixed carbon. It is due the letter-head to say that it does not intentionally lie and without a doubt gives a truthful report of the composition of that particular sample, selected and sent up for analysis at the time. The mistake is made in presuming that those figures have any bearing or that they serve in any remote way as an index of the commercial output of the mine. The above example, in kind at least, is not an isolated case, but may be multiplied in any given year by about 365. What shall be done about it? A number of propositions suggest themselves:

1. Persuade chemists to refuse absolutely to make analysis of "hand samples" of coal or such as have been selected by interested parties without evidence of due care and fairness in sampling. Concerning this proposition it seems on the face of it to afford a possible remedy, but a little scrutiny will reveal the utter impracticability of any such method. It may be that the analysis desired relates to a drill core, or from a bench or layer which is being prospected, or from a part of the seam showing peculiarities that might fit it for special purposes. The chemist can hardly go outside of his sphere to judge of the use to be made of his work. Moreover, the sample is already in hand, charges prepaid with a letter of advice by mail, draft enclosed. Chemists are no nearer sainthood than other people, and the average chemist will do just as you would do if you were one, make the analysis with strict honesty as to your own part in the matter, and leave the scruples as to the use to be made of the results to the man who has paid for them and whose property they become.

2. It may be suggested that the analysis be accompanied by a certificate as to the results, but with a note of explanation or a wording of the report which shall say: "The sample taken by you and submitted for analysis is found to contain such and such percentages;" or possibly a more positive statement, and one which would not require reading between the lines, could be embodied in a footnote to the effect that the above percentages have been determined with all possible skill and accuracy. They are worth in time and ability of the analyst the sum of $10. They are worth to any one wishing to use them about 10 cents.

This remedy appears on the face of it to be more senseless than that first proposed. As a matter of fact it is by far the more practicable of the two, and indeed is already practised by nearly all reputable chemists. Not in that particular manner suggested for a footnote as to the indifferent value of the data, but in none the less obvious a manner readily perceptible to one who is not among that large class of Americans who are said to like the experience of being "humbugged."

The precautionary attitude which the chemist seeks to arouse lies somewhat concealed in the expression made use of in the report thus, "The analysis of the substance *received at your hand* is, etc." Or, "I have made an assay of the *sample selected and sent forward by you* with results as follows."

The surprising part of the matter is that people reasonably intelligent on all ordinary subjects are entirely unmoved by this modest warning of the chemist to be on their guard. This feature of the case has an exact counterpart in the assay and reporting of gold ores. How many gold-mining propositions are floated on the flattering assay of a hand sample!

I had occasion some time since to make an assay of a gold ore which showed values approximating $5000 per ton. The report read as follows: "The sample of ore *submitted by you* has been assayed with results as follows." After floating a large amount of stock and digging a small amount of dirt it was found that it would require the mining out of about 5000 tons of rock to obtain one ton of $5000 ore and people who required this part of the information as a necessary accompaniment of the chemist's figures were saved an unnecessary and avoidable loss.

Coal samples are easily, if indeed they are not more easily, susceptible of juggling than samples of gold ore. This brings up the very important topic of the sampling, but as this bears also upon every topic pertaining to the chemistry of coals it will be discussed more fully under another section.

A third remedy, or perhaps antidote, for this promotional use of chemical data is to make more of an effort towards the enlightening of the public as to their meaning. To offer more frequent interpretation of their value and make commonly available such information as people everywhere may familiarize themselves with and thereby be enabled to make intelligent use of the facts set before them, this is always a rational and sane proposition and furnishes the chief incentive for preparing this paper.

To sum up, therefore, under this first heading as to the advertising or promotional value of coal data, we would say, in general, such data, without being accompanied by a strict history of the samples and the method of taking, are more apt to be misleading than otherwise. If they have any value whatever it will be by the application of one or two very simple principles as follows: Coal the world over is made up of two things, combustible matter and material that will not burn. Now the intrinsic worth of any coal resides in the total percentage of combustible matter, and what the chemist actually sets before us is an indication of the amount of this material together, of course, with the figures for the non-combustible matter. Now fortunately this combustible substance is much the same everywhere, and at least in a given type of coal does not vary widely in its heat-producing qualities. Therefore. if a dealer advertises coal with 3 per cent ash and 2 per cent moisture, it is only necessary to ask him if he will guarantee deliveries which will average 95 per cent of combustible and a total of 5 per cent non-combustible. If he says he will, and does it, then his coal is just as good as his advertisement proclaims.

This brings us naturally to consider the second use to which chemical data may be put, namely. to serve as the medium for regulating the conditions of purchase and sale, or as a contract basis. There is no denying the fact that for large users at least the coal business is making rapid strides towards a specification basis. And why not? Up to the present time the specification has been that 2000 pounds should be delivered for which the pay should be a certain sum. But 2000 pounds of what? Well you say 2000 pounds of material from a given vein or mine. But you soon find it necessary to specify the size to be furnished or the process to which the material has been subjected in preparation for the market, whether it is screenings, mine-run, hand-picked, washed, etc. Without a doubt the increase of transportation facilities bringing all regions into market has called forth this type of added specification to the original avoirdupois basis. But the matter has not stopped and will not remain here. There are other elements entering into the case—for example, the enormous increase in the size of the blasts used in mining, resulting in both an increase of fine material and an admixture of earthy matter. So that the consumer becomes aware of wide variations in the fuel he is getting and that a *ton* of coal is not by any means always a ton of *coal.* And so almost unconsciously a demand has grown up for some authoritative system which should be recognized by both parties to the transaction as a fair basis for doing business.

It is well, therefore, to call attention to the work of the American Society for Testing Materials which has appointed a special committee on coal specifications. The report from this committee will be due at the coming meeting of the Society, June 29, 1909.

It is assumed at the outset that the spirit and purpose of a specification shall conform to the principles enunciated by Dr. Dudley, president of the society, and given in connection with the committee from that society appointed to consider the whole matter of coal specifications. They were to the effect that the proper basis for any specification shall be:

1. That the consumer shall get what he pays for, and
2. That the operator or dealer shall get pay for what he supplies.

A few facts concerning the analysis of coal where contracts are involved may be here in order:

1. How important is it that we should have chemical data? For reasons already referred to, coal may vary in quality over a very wide range. Car lots from 75 Illinois mines were sampled at one time in shipments of two sorts, one in lump or screened form, and the other in fines or screenings. The ash in the lump and screened sizes varied from 8 to 12 per cent; the ash in the screenings varied from 16 to 24 per cent. Facts of this sort could be multiplied indefinitely. The wonder indeed is that any one buying, say, a thousand tons of coal should do so except on specification. Suppose, for example, the deliveries range 3 per cent higher in ash than they should. You have as a result 30 tons of ash that does not belong to you. It is a free gift without permit even, or provision for taking it away if you do not want it. Worse than that, it takes the place of 30 tons of good heat-producing substance and to make up the shortage you are obliged to order an extra carload of coal to supply the deficiency. Let it not be forgotten that it is your intention to buy, not ashes and

water, but *heat*, and the amount of heat delivered should be the ultimate basis of settlement. Hence our answer to this question as to the importance of chemical data in the purchase and sale of coal is—it is indispensable.

Concerning the chemical work itself a few points should be referred to:

1. The matter of sampling. Fairness to both parties demands that a true and representative sample be taken. This is not at all an easy thing to accomplish. It requires experience, good judgment, skill, fidelity, and a thorough appreciation of the conditions which involve the variants. The equipment of talent or training, whatever it may be called, does not ordinarily accompany a cheap boy at 15 cents an hour as the medium for obtaining true and correct samples. A discussion of details of method cannot be entered into here. It is intended to point out the importance of careful sampling. The ultimate quantity turned over to the chemist for his work will average, say, two pounds. In a forty-ton car any error in the ultimate sample of 2 pounds is multiplied for the total of that particular car by 40,000. With reasonable care and intelligence the size of this error should be kept within a + or – value of, say, one-tenth of 1 per cent. This would represent a variable of about 40 pounds per car. I recall an instance, however, where two reasonably good samplers working on the same car secured results over 3 per cent apart, which represented a variation of more than one-half a ton for the car. In this particular case, occasional shovelfuls were thrown out until a 100-pound sample was obtained. In one sample a 3- or 4-pound lump of slate or slaty material was observed, and the question was debated as to the advisability of throwing it out, but the lump was left in with the result that the ash value for that sample was about 3 per cent higher than appeared in the parallel sample from the same car. It is unnecessary to multiply examples showing the need of care in sampling. Some day this work will be done by a mechanical device which will take of the entire car or cargo, as it is unloaded, an impartial one-hundredth part of the whole. This will be reduced in size and subdivided in such a way that fineness of division will keep a constant ratio with the size of the fraction set apart at each stage of subdivision until an ultimate 5-ounce sample is obtained and of a size to pass a 60- or 100-mesh

sieve. But until we reach this ideal stage or device we must insist on a few fundamental conditions:

1. That a large initial sample be taken. Not less for bituminous coals than 100 pounds.

2. That it shall represent as nearly as possible a distribution between the coarse and fines, corresponding to the ratio of these materials in the total car. This means that the bottom layers must be made to yield their quota as well as the top or half-way down, and that the ends and middle of a car which may vary in the process of loading at the tipple should receive equal and impartial attention from the sampler.

3. That the initial large sample shall, immediately after taking, be quickly reduced to, say, a ½-inch size; and that with subsequent quartering and rejection of part a further reduction in size of grains be made so that at the 12-pound state a buckwheat size at the most be secured.

4. A 2-pound sample being thus procured in the briefest space of time, to avoid loss of moisture it should be securely sealed in a tin container or glass jar and delivered to the laboratory for analysis.

A few words concerning the chemist's results are necessary. First, the nomenclature made use of in connection with the moisture determinations has become somewhat confused as to their meaning.

"Wet coal" relates to the sample as originally taken and is the basis on which settlement is supposed to be made. The term does not mean that the coal is wet, indeed it may be very dry, but it has the total moisture present at the time of starting or collecting the sample. A synonymous expression is "coal as received."

"Dry coal" relates to the sample with all moisture removed. It is the condition obtained by drying in an oven at steam temperature. It corresponds to the term "oven dry." This latter term is mainly used, however, by the chemist.

"Air dry" is the condition obtained by spreading "wet" coal in shallow pans until it acquires approximately the same hygroscopic condition as the atmosphere. This is the necessary condition for the chemist to make use of in carrying on his determinations. It is, therefore, a chemical term and perhaps should be confined in its use to the laboratory.

When chemical results are received from the laboratory based upon the air-dry condition, it is necessary to recalculate them to the wet or to the dry basis. To transfer from "air-dry" to "wet" multiply each percentage by 1.00 minus the loss on air-drying. To calculate from "air-dry" to "dry," divide each percentage by 1.00 minus the moisture found in the air-dry sample. These calculations are simple enough but often misapplied.

Having before us the figures showing the percentage constituents of a coal "as received," what interpretation shall we place upon them?

First, let us discuss briefly the meaning of the percentage given for moisture. Suppose a particular lot shows a moisture content of 12 per cent. You say that means that 12 per cent of the coal is taken up with non-combustible matter which takes care of its own removal on burning and, aside from requiring a certain amount of heat for volatilization and also replacing a given weight of what might otherwise burn, it is not an objectionable feature. This is all very true, but it is only part of the possible diagnosis. That percentage, 12, or any other falling between say 8 and 15, marks the coal as of the bituminous type, and it will be accompanied by figures for volatile matter closely approximating 35 per cent and for fixed carbon not far from 45 per cent or possibly reaching to 50 per cent. More than this, it is a bituminous coal of what might very properly be designated as the Illinois type. This great area extends throughout Illinois, Indiana, Western Ohio, Western Kentucky, Missouri, Iowa, and parts of Kansas and Arkansas. This type ought to be discussed in conjunction with another sort of bituminous coal with from 1 to 5 per cent of moisture. The volatile matter in this type bears about the same ratio to the fixed carbon as before, but the region from which it comes lies entirely outside of the area just described. It is found in Pennsylvania, Eastern Ohio, West Virginia, Maryland, Eastern Kentucky, parts of Arkansas, Kansas, and Colorado. We may get a general idea, but a very fair one, as to the relative properties of these two types of bituminous coal in the following manner:

The coal with 12 per cent of total moisture will have in its composition as part of the volatile matter quite approximately a corresponding percentage of inert or non-combustible substance. If now we take into consideration the ash, we shall have three sorts of non-burnable substance in quantity about as follows:

Moisture	12 per cent
Non-burnable volatile matter	12 per cent
Ash	8 per cent
Total	32 per cent
Hence, actual combustible	68 per cent

The reciprocal of this last number is 147, which means that 147 pounds of this coal are required to furnish 100 pounds of actual combustible substance.

Now the same procedure is applicable to the other type of bituminous coal. Thus

Moisture	3 per cent
Non-burnable volatile matter	3 per cent
Ash	8 per cent
Total	14 per cent
Hence, actual combustible	86 per cent

The reciprocal of this last number is 116, which means that 116 pounds of this coal are required to yield 100 pounds of actual combustible material. The relative efficiency or value therefore of these two varieties of bituminous coal will be approximately inversely as these figures 116 and 147. If the Illinois type, for example, is quoted at \$3.00 per ton, then

$$116 : 147 :: \$3.00 : X$$
$$\text{or } X = \$3.80$$

The relative values in actual combustible will be shown on the tonnage basis to be in the ratio of \$3.00 to \$3.80.

Concerning the ash but little interpretation need be given. It has weight both before and after combustion. It involves expense at every stage, in the purchase, in transportation, in modifying or holding back a certain part of combustible from burning, and then in cost of final removal. This tendency of the ash to carry along with it some unburned coal is not often taken into consideration. Suppose a coal with 15 per cent ash passes over or through the grate with 25 per cent of it in the form of unburned coal. This means that 500 pounds of this coal will produce 100 pounds of refuse of which 75 pounds will be actual ash and 25 pounds will be unburned coal. This loss of 25 pounds of coal per 500 pounds fired represents a loss of the original fuel equal to 5 per cent. By the same process of reasoning a coal with 5 per cent of ash, carrying 25 per cent of unburned residue, would require 1500 pounds to produce 100 pounds of total ash. If this, therefore, is made up of true ash and 25 pounds of unburned coal, the latter represents a loss of 1$\frac{2}{3}$ per cent of the original fuel.

The fusibility of the ash, clinkering, etc., are so much the property of the individual furnace and the temperature at which it is run that little can be said on this point other than that, in general, high sulfur stands for certain conditions or constituents which ordinarily mean an ash of lower fusibility and greater tendency to clinker than otherwise, though this rule has occasionally marked exceptions.

Concerning the ratio of volatile matter to fixed carbon, little need be said. Our knowledge of the requirements for a combustion chamber have moved forward so markedly in recent years that we should be able to burn our combustible equally well whether in the form of volatile matter or of fixed carbon. However, with ancient settings, as with household appliances, a coal with high fixed carbon and low volatile helps out a poor outfit by consenting to burn more largely on the grate rather than up in the air, or not at all, as is the case for example with a very large percentage of the volatile matter in the ordinary house heater.

These facts are suggestive merely as to methods of interpreting coal values. The subject is too large and complicated for detailed discussion. Especially is this true of the third grades or forms of fuel, unit-coal, etc. These matters, moreover, pertain to the engineering side of the coal question, and should not be taken up here.

THE USE AND ABUSE OF FUELS

H. M. WILSON

Mr. Herbert M. Wilson: Mr. President and Gentlemen of the Water Works Association: Your Chairman last evening kindly, at my suggestion, postponed the informal talk which it was understood I should give on the subject of the use and abuse of fuels, and the Government's connection with the testing and purchase of fuels, until this time. This was done because after arriving here and looking at the papers which have been presented, I realized that the three papers of Mr. Bemis, Mr. Taylor and Professor Parr covered much of the ground over which I will take you, and that it would simplify matters for you and for me if those papers could be presented beforehand, so that I might approach my subject as a discussion.

The United States Government, as you may realize, is the largest purchaser and largest fuel user in the United States. The coal bill of the Government for the present fiscal year will probably aggregate $7,000,000. Some of the contracts, notably one for bunker coal on the Panama Steamship Line from New York to Panama, and the coal purchased for the use of the Isthmian Canal Commission at Panama, for the first, 100,000 tons per annum, and for the second, 400,000 tons per annum. In addition the Government is purchasing coal through the Treasury Department for over two hundred public buildings in different parts of the United States, and accordingly is purchasing all kinds of coal. Under these conditions it is rather fortunate for the consumers of coal, as well as for the country at large, that in the preparation of the contracts and examination of the coal, and approval of the material as delivered and payments therefor, it all goes through the technologic branch of the Geological Survey. In that way we have an opportunity to learn something more of the coals of the United States than has ever been available before.

In addition, we are testing coals for Government buildings in the City of Washington, coal for Navy Yards on both coasts, coal for a great many Army Posts throughout the United States; not yet for warships, but that is coming soon.

The first step in the direction which Mr. Bemis has suggested was taken when the first bunker contract was let for coal for the Panama Steamship Line; the most important step was taken just before President Roosevelt went out of office, when he appointed a General Purchasing Board on which is a representative from each of the Government Departments. When that board met recently in Washington, it was ascertained that a number of the Bureaus, including our home District Government, were not purchasing coal on the specification basis. When we came to analyze the bids we were fortunately able to show that the contracts, which were let on the old basis, were in several instances higher; that the prices bid were higher even from the same dealer in the same cities than prices under the specifications; and in consequence there was ordered a rebidding, and nearly all of those who had not originally bid on the specifications are now believers in their advantages. Immediately thereafter the Navy Department made inquiries regarding the method of purchase on the B.t.u. basis, and there were examinations of the purchases for naval vessels afloat which, I believe, must ultimately lead to some form of specification basis. Their conditions are quite different from those of any other consumers. They feel great hesitancy in departing from the use of any coal which they have used in the past that they know gives the efficiency they want. They cannot afford to have coal in stock which will not give their highest rate of efficiency for their engines in case of emergency. It only remains for them to be assured, I believe, that there will be no falling off in the quality of their coal, for them to arrive at some basis upon which such purchases may be made on this system.

The remarks that have been made heretofore have referred chiefly to the bituminous coal purchases on the specification basis, and chiefly on the basis of B.t.u. The Government has been buying anthracite chiefly in Washington and in a few other places on specification basis, which takes no cognizance of the B.t.u. but of the ash content almost exclusively. That has proven so satisfactory that the Treasury Department, which is under the necessity of buying such coal throughout New England and New York State, felt that they would like very much to secure bids on that basis.

For two or three years past it has been practically impossible to get coal dealers, who have had a fairly close control of the situation throughout New England and New York where the territory is fairly well farmed out, to bid on anthracite coal on the specification basis. Some months ago at the time of the letting of these contracts, the Treasury Department came to us to inquire if it were not possible for us to make further effort to secure bids on that basis. So I sent Mr. Riefkin, one of our principal fuel inspectors, to that section of the country, and thanks to the cordial coöperation of the Treasury Department whereby they furnished him with open contracts, he was enabled to take these contracts about from one large coal dealer to another in Boston, and explain the meaning of them. In that way he got, I think, as many as eight bidders in Boston. He went next to Rochester, to Syracuse, to Albany, New York City, and in places where it was absolutely impossible to teach the coal dealers after careful explanation; and as I say, because he was able to make out contracts for them and notified them that their bids would be let with those contracts, within a few days before he left the city he took the matter up through the Treasury official of that city and he got bids for the next fiscal year in all this region on the specification basis. I think that the anthracite situation has been materially changed in that region as a result of this effort of the Government.

Many coal dealers merely know that they are handling good coal and making money on it. They think they can always get their price, so that it is of no moment whether or not it contains more or less ash, or more or less B.t.u.'s Such a man is satisfied with his methods and is content to know nothing more about the coal than simply to be a business dealer in it. Coal is coal to him. Coal is not coal, however, to everybody, and coal is not the same coal if there is not the same fuel value in it.

The Navy Department has been buying coal from well known dealers in the semi-anthracite region of Maryland and Northern Virginia, Southern West Virginia, the Pocahontas and New River districts, etc., and has heretofore inserted in its contracts only the statement of the bidder's name and the mine from which the coal was coming. When they came to look into this question a little further, they took a first and very important step, in my judgment, in requiring certain data which would furnish them a more correct basis, that is, they not only required the statement of the mine from which the coal comes, but the seam from which the coal comes. It is important that the geological formation or seam should be shown. In our larger and deeper mines they go down through several seams, and you can take coal out of a lower or upper vein and one may run a certain number of B.t.u. and so much ash, while the other will prove to be quite a different material. No detective can follow the output from a certain seam; you do not know whether it will be loaded into a car that will go to Cincinnati, or to the seaboard at Norfolk.

In order that we may know something of the character of the coal being delivered to the Government, and might beforehand have some knowledge of its quality, we have undertaken a very careful mine sampling of coal. We have had our mining engineers who have been doing the sampling take mine samples not only from all the important coal fields of the United States, from Washington to Alabama, but in various portions of those coal fields and their different seams. We have not yet covered the whole country by a long way, but we do know a great deal, about six or seven hundred typical coals of the United States. Those mine samples are very carefully selected, put in hermetically sealed bottles and mailed to the chemical laboratory in Pittsburgh, where approximate analyses and other calorimeter determinations are made; and as a result when there is a bid made on a coal from a certain mine or a certain region, we are able to tell a great deal about how that coal is going to turn out.

Now we are going a step further than that; we are making ultimate analyses of typical coals from all over the United States. This particular year we are going into it very heavily throughout the Eastern field, on account of important Government coal purchases. This gives a vast amount of information of a kind that we want, information that one would scarcely appreciate the importance of at first thought. The fact of the matter is that when a coal is offered from any region, the examination of the mine sample and the ultimate analyses that we have previously made enable us to tell pretty nearly what vein that coal comes from. Our geologists who are studying these coal analyses very carefully claim in many instances that they can positively state as a fact and have every reason to believe, that we will reach the point when, with all these analyses of record and published, it will be practicable for a man who is familiar with the coal fields of the United States to say with certainty that a particular coal comes from a certain mine, and even the particular vein in that mine. From the analysis of that coal he can say whether or not it is the particular coal it is represented to be, or whether it belongs to some other formation. That is going to be one of the most important items in detecting whether or not the coal which is specified and bid upon is actually being delivered, not only so far as its B.t.u. and ash content are concerned, but as to the actual fact as to where it comes from.

It is hardly necessary to tell you, therefore, that the question of the distribution of the coal throughout the United States and the selection of coal from different parts of the United States is an important item, especially with buyers who buy from more than one field or market. Anthracite coals come from one region, Eastern Pennsylvania. They have some fairly good anthracites, a little high in ash, in Arkansas, and semi-anthracites, good high carbon steaming coals, in Central Pennsylvania, Virginia, Southwestern West Virginia, Maryland, and other parts of the United States.

Coking and gas coals come chiefly from the Pittsburgh region, so-called, and from West Virginia, Tennessee and Southern Colorado. Through Indiana, Kentucky, Illinois, Ohio, the central field, and in Michigan, the northern field, and in Iowa, Missouri and Kansas, the western field, the high volatile steaming coals are found. In Colorado they have a variety of fairly good anthracite coals, also steaming and coking coals. In other portions of the Rocky Mountains, Colorado and Washington, there are some fairly good sub-bituminous coals; but the important fuel of the far West is the lignite material which is low in carbon and fairly high in volatile matter, generally quite low in ash, and high in moisture.

The Government specifications for coal purchases of anthracites provide that—no standard has been used, but we will speak of it as a standard for simplicity of description—bidders shall furnish coal that shall have not more than ten per cent ash, and that any variation from ten per cent, if two per cent plus or minus, shall be penalized fifteen cents per ton for above in ash and shall receive a premium payment of fifteen cents per ton on the same proportion below ten per cent. There are other modifications of details which I will not go into. The contract is published in Mr. Taylor's paper. For pea, sixteen per cent ash, with a variaton of two per cent plus or minus, offering a deduction or receiving a premium of ten cents a ton. Buckwheat, eighteen per cent with a variation above, being penalized at eight cents per ton.

Only last year it was necessary to remodel some of the furnaces of the State, War and Navy Department Building, and as a result of the method of purchase the superintendent of the building was convinced that he could use a cheaper grade of anthracite, Buckwheat, and in the first year following there was a saving of over $15,000 made on that coal bill. He is able to get all the efficiency he wants out of his boilers, and he pays a very low price for coal. This buckwheat coal is 18 per cent ash, and it has not troubled him at all. If the ash runs a little higher, there is a reduction, which accounts for the difference in the heating value furnished. Of course there is a limitation in such cases and in most cases, on the amount of ash, because you do not want to handle too much ash.

The bituminous coal contract published in Mr. Taylor's paper fixes the standard at 14,100 B.t.u., with the premiums, or deduction, plus or minus, of one cent per ton for every B.t.u. variation from the standard. There is a slight allowance for ash.

I think perhaps a remark that was made by Mr. Taylor might have been misunderstood, concerning his feeling toward the settlement for coal on a basis which takes account only of B.t.u. As I understood him, it is fair to the dealer to pay for the high value only on a high value basis, with the slight modification on account of ash because of the difference in efficiency produced by the increase in ash. I think it goes without saying that the prime factor in the specification method of purchasing coal is the fact that you pay for what you get; you pay for the number of heat units you get, and you get what you pay for. It is perfectly fair to the men on both sides. There should be no effort in a contract to make money out of the coal dealer, to gain a big profit out of him by penalizing him too heavily for too large a variation from the standard.

I noticed Mr. Bemis remarked that in their contract they make deductions of three cents, I think it was—

MR. E. W. BEMIS: When it is below 12,000; otherwise only 1½ cent.

MR. H. M. WILSON: I had understood you to say that you thought that was high.

MR. E. W. BEMIS: Three cents may be high, but that was in the nature of a penalty.

MR. H. M. WILSON: I have my doubts as to whether there is any wisdom in fixing specifications so as to penalize. I think the fair thing should be done to the dealers, so the dealer may coöperate with those who are purchasing coal. You should try to fix your specifications so that you only penalize to the extent which will reimburse you for any loss for failure to receive heating value.

The ash content comes into the matter in another way, which should not be overlooked; in fact, in two ways, one of which I think Mr. Taylor took account of, namely, that the higher the ash content, the less combustible value there is in the coal; and as the ash increases, it is fair to presume that there is an increase in the percentage of combustible loss through the grate bars. There is a variation of twenty per cent of combustible loss in ash in well handled plants.

From careful examination and statements made to us, and experience based on a great many analyses that we have made in our tests around Washington, we have found the loss in combustion in the ash runs considerably higher than that, so that there should be some allowance made for that in your specifications.

The other point is, that the more ash you get the more it costs you to remove it. There should be a corresponding deduction or allowance made to cover the additional loss in handling the ash, as well as for the loss in heating value.

An instance of that sort has come to my notice recently, in talking with Mr. Taylor, who has had a similar experience, wherein an engineer of a large Government power plant did not like to use a certain B.t.u. coal which the specifications had forced upon him. That may have been the only reason. We find sometimes there are other reasons why the engineer does not want to change his coal. This engineer claimed that he had to have additional men in his boiler room to handle the coal, and that the handling of the ash had been quite a charge upon the men; that he was getting twenty or thirty per cent more ash than he did on the old coal. The matter was referred to us, as all such matters are, to find out the trouble. In examining the daily delivery of coal, samples being taken for analysis as our men inspected it, we found nothing in the analysis to account for the trouble complained of. The variation in ash was very small and would not account for a drop of, say, fifteen per cent in efficiency, and an increase of thirty per cent in ash. I am sorry that Professor Parr did not deliver his paper here, but most of you have it and you can read it. I am going to state briefly some of the things that are in that paper, as they are the things that we are doing too.

One of the gentlemen asked the question of Mr. Bemis that bears on the same point, as to how conscientiously these tests are made? We sample the coal as received and make an analysis of the coal, especially calorimetric determination. The sampling is, in my judgment, by far the most important feature of it. All good chemists of little experience can make a calorimetric determination and can determine the amount of ash in every coal. Unfair sampling is the easiest possible thing to bring about without any intent on the part of anybody to arrive at anything but proper results. It is very difficult to get a fair method of sampling. That is one of the open questions today.

I may say for the benefit of you who are interested in such matters, that the American Society for Testing Materials, which is doing a splendid work in many regards, a year or more ago appointed a very large committee on coal specifications. The committee is divided into a good many sub-committees, as, for instance, on gas coals, steaming coals, etc. The reports of these committees will be of great value to all of you as showing how to prepare specifications. I presume as time progresses they will come into a better understanding with other people handling coal in this way, as to methods of sampling. That, considered from the point of vew of the Government—which is a great owner of coal lands and in which, following President Roosevelt's conservation policy it is anxious to conserve the coal supplies of the country by seeing that they are not wastefully mined and that each coal goes to its best use—we are first interested in; but the private consumer is not, but he may be when he comes to see our report. We are first interested in the mine sampling, and only the Government can do that. No private purchaser or state concern would be allowed to go in the mines; but thanks to the thirty years of good, honest history of the Geological Survey in the inspection of precious metal mines throughout the United States, we are in fairly good favor and we are permitted to enter coal mines when we please and to sample their coals. The data which will be secured in that way will be of the greatest value to the country at large, and to the individual analyzer of coal.

The mistake is frequently made of taking your published mine samples as a criterion of coal to show which a company is delivering, because in transit that coal changes materially, and the mine sample is only the average mine sample because it is taken from one part of the mine, and in the course of a year you are working somewhere else. The only fair sample to buy on is the coal as delivered at your plant. The coal as received has undergone numerous changes. A great deal of dust has sifted into it in transit, and perhaps it has been rained on. The slate that is in the coal becomes shaken down, so that if you sample from one part of the car you may get a coal perfectly free from moisture, while from another part of the car you get coal with a great deal of dust; or if it is from the bottom of the car, a great deal of slate. The only fair way is to take a shovelful out every now and then as the coal is run into the bin, so as to get a representative sample from the bottom to the top, from one end of the car to the other. It takes a big sample, one hundred pounds or more, which will include lumps, slate, etc., that can be parted down and parted again and again, until you get down to a fairly representative sample that can be crushed and powdered, put into a hermetically sealed bottle and sent to the laboratory. That is our method of handling it. On little deliveries made in Washington of only a few tons at a time to some public building, we take several shovelfuls out of that few tons. On a contract like the Panama Steamship Company, of 400,000 tons per annum, they are shipping two steamship loads a week, each steamship load meaning a good many train loads, they have to have an inspector on the dock all the time, and that inspector does not, and cannot, sample every car. If he did he would burden us with an unnecessary number of samples for analysis, and we could not afford to handle so many chemical analyses. So we have for a long time been sampling only about one car, I think it is. I think we take one sample out of one-hundred tons, one car in five. I may not be exact, but that is my recollection.

We are reaching a point where we feel we are not sampling closely enough, and we are taking samples more frequently. Such sampling involves the continuous work of one inspector on this one purchase, and two or three chemists are kept busy making a number of analyses. But it pays to do this. The company feels that it has saved a good many thousands of dollars on the coals purchased in this way. I do not want to take up too much of your time on this subject. There are many other things that may be said, but I think the subject has been fully and well covered by the papers.

One of the things that the technologic branch of the Geological Survey is endeavoring to do is, to find out how you can use the low grade coals of the United States. We have a vast amount of very low grade coal, more low grade than high grade coal. One of the first things we undertook at Pittsburgh was, to examine the so-called waste coals of the Pittsburgh region in order to determine how they could be efficiently used so as to make them available for consumption, coals which are not in the market but which are cast aside as waste. Thus we hope to save much of the mineral resources to the wealth of the country, the loss of which is now perhaps adding to the cost of coal. After looking through a number of the mines there we found one concern that was willing to coöperate with us to the extent of taking out and furnishing us a lot of their roof coal which they were not handling in that region. That is a region where they want the very highest grade of coal for market consumption, the Connellsville coal region. Coal which runs only seven per cent ash is not of very much account for metallurgical purposes.

When we got hold of our first car-load, which we received delivered at eighty-eight cents per ton, we began to run it through the Heine boiler for producing power, light, etc. One of the smoke inspectors who had heard of this low priced coal came there, and wanted to know what kind of smoke we were putting through the stack. He asked us if we had a license. We told him no, because we were on Government land, but that we would be glad to coöperate with the city, and asked him to go out and look at the stack. He did not find any smoke. As soon as we got our analysis we found that the coal did not run much over twelve per cent ash—about twelve or fifteen per cent. It was what would be considered a very high grade coal in most parts of the United States, but in that particular region it was low grade coal and was not being marketed at all. We did not think we were doing anything very fancy in burning that coal without making any smoke.

We have had a great deal of difficulty, in fact, in getting sufficiently low grade coals to suit our purposes. We have an equipment there for steaming tests, as we call them, which are regular boilers, two Heine water-tube boilers, of 250 horsepower each. They are in regular commercial use, furnishing power, light and heat. One of them is fitted with a mechanical stoker of one type; one consists of a hand fired boiler; and the hand fired boiler, as Mr. Flagg told you last night, is connected with the long combustion chamber which was built for experimental purposes, and has at the furnace end a mechanical stoker. We are using as low grade coals as we can get from different parts of the nearby fields, and we are learning how to burn each one of those coals smokelessly so as to produce the right efficiency of the boiler. We have had no difficulty in doing that on the very few preliminary runs on any of the coals which have yet reached us.

Another thing which we are endeavoring to do is to learn how to use these low grade coals in the gas producer. We have made a great many tests in the gas producer with coal from all over the United States, which have been published and are accessible to all of you. They show how each coal should be operated in certain types of gas producers in order to get a better efficiency out of that coal than you may be able to get from the same coal operating under a steam boiler.

For certain low grade slack coals we find that the most efficient way in which to use them is by briquetting them, compressing them into little small nodules not unlike anthracite in handling and burning, except that there is a little bit of binder to it which makes some volatile matter. We burn these through a long combustion chamber where we give the gases of combustion an absurdly long travel, and have sampling holes every five feet so that we can sample the gases at different parts of the cross section, and take simultaneous orificial samples, and measure the temperature at different parts of the chamber. Thus we hope to find exactly the length of travel to give each coal so as to have perfect combustion before the gas reaches the cooling tubes of the boiler. We have built an absurdly long chamber, as I said, so as to give it all the travel it needs, and now we are finding how much to cut that chamber down so that it shall not have any more than it does need.

I think there is nothing more I can add other than to say that the Geological Survey has already published a great many bulletins giving all the details of these tests, and any of you that are interested in making purchases of coal by specification, or who wish to ascertain what is the best coal locally available to you, or the best way of burning any coal for certain purposes, put in under a steam boiler or under a gas producer, or by briquetting, if you will write to the Geological Survy we will be very glad to give you any such information that we have available for distribution.

DISCUSSION

Mr. J. M. Diven: As one of the managers of the small plants, where the facilities for having coal analyses made rapidly are not convenient, I would like to know from some of the gentlemen who have analyzed coal if there is any simple method of making analyses of coal sufficient for small plant purchases, say a plant using perhaps a carload of coal a week. Is there any simple method by which one can make analyses, or would it be necessary to send samples away for analysis?

Mr. M. F. Corin: Here is one test which is practical and easy to make. The apparatus required are, an air bath, a desiccator, a tripod, a crusible and a balance.

The method is as follows: Weigh off two grams of the coal to be tested in the crucible (the coal should have been carefully sampled and powdered), heat it in the air bath, up to about 100 to 105° C. for two hours. Cool crucible in desiccator and weigh *after five or ten minutes,* the difference *is moisture.*

Now heat the crucible with cover on, with content over a bunsen burner with a long blue flame, so that the entire crucible is covered by the flame, until no more flames are visible around the edges of the cover. This flame is the volatile matter escaping from the coal and ignited by the heat from the bunsen burner. Now cool in the desiccator and weigh: the difference is *volatile matter*.

The *fixed carbon* is now determined by heating over a bunsen burner with a strong flame until all the carbon is consumed and only the ashes are left. Cool in a desiccator and weigh: the difference is fixed carbon and what is left in the crucible, naturally, *the ashes*.

Sometimes the heating for the determination of volatile matter is carried on for exactly five minutes and the crucible thereafter cooled in the desiccator and weighed.

Volatile matter plus the fixed carbon naturally *indicates* the heating value of the coal.

The heating value is also easily determined by the use of a special apparatus, the calorimeter.

You surely will find this method of analysis quite sufficient for a small consumer. Although it is not absolutely necessary for practical test of this kind, it is, however, advisable to use a good balance for which one has to pay about $100.

I would like to add to the above that the calorimetric test for the determination of the value of the coal is not altogether sufficient because a coal can have high heating value, but notwithstanding that be impracticable to use in a certain boiler on account of its character.

The determination of volatile matter and fixed carbon will at once tell us more about the character of the coal which at many times is of great importance when judging the coal. The speaker would more highly recommend that any one who can afford to do it, furnishes their factory with, not only the apparatus for making the test as described above, but also with the apparatus required for determining the heat value. As in such case no mistake need to be made in judging the coal.

Mr. E. W. Bemis: We use a Hemphill calorimeter. The Emerson is also said to be very good, and there are doubtless many others. Either of those I have named costs from $100 to $150. We have only one. We do not attempt to test except for calorimeter results, for the sake of ascertaining the heat units. I will ask Mr. Schulz to explain more fully, because he has had personal charge of it.

C. F. SCHULZ: After bids for coal are received, which state the prices for coal and the names and locations of the mines from which the coal is to be furnishd, each bidder is notified to send in a sample car of the coal he is bidding on.

Evaporative tests are made of this coal, each test generally lasting ten hours, and from six to eight tons of coal are consumed during each test.

This coal is weighed out in two hundred pound lots and as each lot is weighed a small sample is taken and laid aside. At the end of the test these accumulated samples are thoroughly mixed and quartered and a small quantity is taken for chemical analysis and calorimetric tests.

The evaporative tests determine what it costs, with each kind of coal, to evaporate 1000 pounds water into steam from and at 212° F.; and this determines to whom the contract shall be awarded.

These tests are checked by comparing the results thus obtained with the results of the calorimetric tests. We generally find that the coal which gives us the cheapest evaporation in the boilers is also the cheapest on the heat unit basis. I do not remember of any case where the results of the two tests have materially disagreed. I believe that answers the question asked.

MR. EDWARD H. TAYLOR: I want to say one word about this proposition of making your own analyses in your own plants in a cheap manner. I have known more people to get in trouble and into controversies in that way than in any other, because they have made imperfect analyses. I have done a lot of that work myself and I am perfectly competent to talk about it, because I got into trouble at first by not having the best instruments and not doing the work in the most careful manner, so as to get results that corresponded with boiler tests. I had a paper sent me by a professor of engineering who was located in one of our largest manufacturing plants in this country, who says that the B.t.u. in the coal doesn't have any effect on his boiler tests at all; that although the B.t.u. changed to the extent of four hundred or five hundred it doesn't alter his boiler conditions at all. I asked him how he got his B.t.u. He said he used a formula and he ran his determinations in a crucible, sometimes high and sometimes low, sometimes one temperature and sometimes another, and then he calculated it. The result was that he did not get any results at all.

Mr. W. S. Cramer: I can probably give you a little information along the line of the small water works man. I was brought up against this proposition two or three years ago while handling a coal test at Lexington, Ky. I was a little bit skeptical and had my own ideas. I hadn't any idea that I was cut out to analyze coal as I am not built along those lines. I went to Cincinnati to consult with a couple of friends, and they were making heat unit tests in their own plant. I went into the room where they had the apparatus at work and didn't pay much attention to it, because I didn't think I was going up against the game very strong any how; but I listened to what they had to say. They wouldn't let me get close enough, in the first place, for fear my breath on the thermometer would change it. I think it read up to 1000° F. I know one of my friends wouldn't carry his cigarette into the room for fear it might affect the thermometer. He made the test, and they commenced making calculations. They made deductions for room temperature, and deductions on top of deductions until I didn't know where the deductions ended and the original proposition commenced. I went back home and passed the matter up to my people. No coal tests for me. I was not built along that line and don't want anything to do with it. Such tests can only be made in a well equipped laboratory. It would not be satisfactory to me, if I were a coal dealer, to have it done anywhere else. I think the trouble has been that some two or three years ago the country was flooded with circulars advertising cheap coal tests by men who said they would come to your plant and teach you how to test coal on the heat unit basis, whereas those men didn't know anything about buying coal, not even the first principles of analyzing it. I liked what Mr. Smith said in his paper last night. That was the best thing I ever heard with regard to the method of burning coal and getting the value out of it. It is one thing to buy a B.t.u. and another thing to get the work out of the coal. On that line Mr. Flagg and the paper by Mr. Randall taught me something, and agreed with some of my own tests. The coals of West Virginia and Kentucky are the ones we burn. I could always get very close comparisons up to 13,500 B.t u., above that there were wide variations, such as shown by charts. So, I have come to the conclusion that if you get above 13,500 B.t.u., there are some aristocratic heat units that do not work at all. That has been my experience. When you get above 13,500 B.t.u. there are some of them that get away from you. I can't get them to work, and I have just come to the conclusion that there must be a select Four Hundred in the heat unit family.

Mr. E. T. Sykes: I think I ought to put in a word or two for the benefit of somebody else. I believe very strongly in this B.t.u. business. Coal means something in Minneapolis. We always thought we had to get our best coal from the east, but we are now burning a low grade of coal from Illinois, and are saving ten to twenty per cent. That has been entirely developed on the B.t.u. basis. We are using the Hawley down-draft grates, with hand stoking. This Illinois coal is a low grade of screenings and produces about twenty per cent of ash. The additional amount of ash handling is a factor not considered, but should be. The use of this grade of screenings makes much more labor for the fireman. The effect of the greater economy in using this low grade of coal is to reduce the price of the eastern coals.

Mr. W. H. Friedrich: There seemed to be quite a demand for a simple way of testing coal. So far as the B.t.u. is concerned, in my experiene, it amounts to but a little. I first take into consideration what coal is best adapted for the existing conditions, and after knowing this, I try a few cars of coal from several firms and see which evaporates the most water per $1 of fuel cost. This is done simply by weighing the coal each day and measuring the water, which most plants would have appliances for. This is a very easy method and does not require one hour extra labor in twenty-four and, if done daily, you know just what every car is doing and as soon as you are dropping off on evaporation, you know it the next day, and you can look for the trouble at once. It may be in the coal or it may be something else, but you know something has gone wrong and you can look for the trouble right away, it don't run six months before you find it.

If a plant has no meter, a good way is to have a barrel, or better, a tank that will hold enough to run five or six hours, and when this is empty, refill. Knowing the capacity of the barrel or tank, it is a very easy matter to know exactly how much water has been evaporated. Also with the weighing of coal, if one has no scales, one can weigh a few wheel barrows of coal and get an average, then by taking a little pains to load them all alike, it is a very easy matter to get very accurate weights in this way and whenever possible, check with the car weights.

We have kept a daily record of the coal used and the water evaporated per $1 of fuel cost, and in the past four years, the fuel expense to April 1, was as follows:

1906	$7584.85
1907	6632.02
1908	5866.60
1909	5405.42

We have added each year about one hundred and twenty customers, which increased our 1909 income $6774.35 over our 1908 income, but still it is costing us less money for fuel.

While some fuels burned under one condition would be entirely satisfactory, it would not do at all under another condition, yet the B.t.u. would be the same. For example, two years ago, after carefully studying what kind of stoker would be best adapted for our work, we installed the Jones underfeed stoker and found, after trying a number of cars of coal, that a certain grade of Pittsburgh No. 8 would evaporate more water per $1 of fuel cost than anything we could get, while this same coal hand fired, we could not pull our load two hours. The coal, when heated, would run and fill the grates so the fire had to be pulled out and let cool so a man could get in and cut out the clinkers with a hammer and coal chisel, yet the B.t.u. were the same in either case, only used under different conditions.

While we have made a considerable saving in fuel from year to year, in the past three years, in spite of a gradual increase in business, it has not all been due to keeping tab on the coal, but by studying our conditions and getting the right thing in the right place, is what is and has been increasing the efficiency of our plant, and this we hope to continually do.

Mr. H. F. Dunham: In the case cited, where the chemical analysis showed a small per cent of ash and the boiler room test developed thirty per cent, I think it would be interesting to know about the cost of the analysis, and the laboratory work as carried on by the Government, based upon the same unit of measure of coal that was examined and pronounced upon.

Mr. H. M. Wilson: With regard to this inquiry, Mr. Chairman, I am not at liberty to say anything more than I have. Our chemical analyses are made in such a way that it is impossible to believe the error was there. We are compelled to make them so because we are buying so much coal, and we have got into enough controversies to know our ground. The only thing that could possibly be questioned might be the sampling. I do not believe the sampling was at fault in this case. Since then the sampling of coal has been turned over to us, the particular purchasing authority desiring to be relieved of the responsibility. So far as analysis are concerned, we make them in the cheapest way. We take a number of samples, as Mr. Taylor does, and make our regular analysis in the purchasing laboratory. We keep a check sample for reference and send a check sample to the Pittsburgh laboratory, where another chemist comes naturally in contact with it. Then the Purchasing Commission in Washington may make another check analysis, so that we are pretty safe on our analyses.

At this point I might add to some of the comments made by Mr. Taylor on the matter of amateur analyses. Perhaps from the point of view of a Government man who has no axe to grind. I would certainly advise any one making purchases of coal in this manner to make arrangements whereby their samples may be sent, properly sealed in cans or bottles, by mail, to some reliable laboratory, which would relieve you from controversies with the contractor. You will have a great many such analyses, but if your analyses are not just right, you will find the coal dealers will not be willing to sell coal in that way without knowing what they are selling.

So far as the question of the cost of such analyses is concerned, Mr. Taylor has told you what it would cost to have it handled in a commercial laboratory. Proximate and calorimetric determinations cost us, I should say, something over $2.00 for anaylsis. The figure is not high.

Mr. E. W. Bemis: We know that the local price in Cleveland is $2 a test. It costs us that much. We have been paying a man $100 a month who doesn't do very much else except analyze those fifty samples. Probably it doesn't cost us quite

$100 a month for the pure testing. We get somewhat over fifty samples for testing. We have never got it down so as to fix the cost. We place a little more reliance on our own man who works under our own directions. Of course the cost might be different in other cities.

MR. H. M. WILSON: I should be glad to furnish such information to any of you who are interested in the exact cost in our laboratory. If you will address me at the Geological Survey in Washington, I will give you the exact figures. We have a good many chemists on the work, and we know exactly what the average cost is in a large laboratory. The matter of reducing that to cost per ton is another thing altogether. That depends upon the number of samples you take out of a carload in a day. Where we only take one sample the cost per ton is very much lower, and on one hundred tons the cost per ton is very much lower than in the case of wagon-load delivery when you take one sample for analysis per wagon-load. That factor depends altogether upon the question of the coal and how you sample it. For a man who is getting coal in a very small way, I cannot conceive that he would be the gainer in any way by merely sending a single sample and paying $10 for an analysis, although it must be worth something like that to make single calorimetric determinations; but if he enters into a weekly or monthly arrangement so that his samples can be analyzed as they come along, the rate could be reduced to a very moderate figure.

MR. E. W. BEMIS: I want to correct one thing I said. We have two tests each time by our man. They are taken in duplicate; in other words, we really get one hundred tests per month although there are only fifty cars. Then we keep a sample of the coal sealed up, as has been suggested by someone else.

MR. A. A. REIMER: I should like to ask Mr. Wilson or Mr. Taylor if they can give us some idea, based upon the quantity of coal consumed per year, as to whether it would pay a small plant to begin purchasing coal upon a contract on the B.t.u. basis, say a plant that is using five hundred tons a year; could sufficient saving be made under that plan to justify the adoption of it?

MR. EDWARD H. TAYLOR: The cost depends somewhat upon the manner in which you receive your coal. I have one contract that costs $10 a year. We only make two analyses. They receive between 500 and 750 tons and they get it in three or four days just as rapidly as possible, and put it all in their bunkers at one time. You have to take into consideration the price you pay as well as the tonnage you handle. If you are burning fifteen hundred tons and pay $1.10 a ton, it would not pay to have the coal analyzed; but if you are burning three thousand tons of Illinois coal a year, it would. We take this plant under our care and figure out at the first of the year how much it costs. For the entire tonnage we handled last year it cost on an average one-quarter of a cent a ton on the entire million and a half tons (1,480,000 tons). But as you come down in quantity it costs considerably more than that, when the accounts are small.

Mr. A. A. Reimer: Does it make any difference if bituminous instead of anthracite coal is used, or vice versa?

Mr. Edward H. Taylor: No, the same for the one as the other. The drawing of the contract and everything is included in the fee. We figure on the basis of about $5 an analysis, and make just as few analyses as possible. A great many plants we only make one analysis a month, but get samples every day, or from every car, which gives better results.

Mr. E. M. Nichols: These papers have been interesting to me, although at present they are not probably understood. I call to mind that some fifteen years ago I had occasion to determine the value of coal offered on a certain contract. While I did not go into any tests in the way of chemical tests, we did make practical boiler tests, and from that determination the calorific value. They were made practically on the lines that have been laid down here, but merely in the boiler room. It occurs to me that a small consumer could very easily carry that out from year to year. It is not much of a job to rig up a battery of boilers so that you can make a test every week, if you choose, of an eight hour run, assuming that you have three or four boilers.

There are some things I think the papers have not brought out that have come to my knowledge in times past, particularly with regard to burning inferior coal. It does not always follow that the value is determined by chemical test. In other words, there enters into the thing the cost of handling fuel and the cost of handling ash. Mr. Wilson referred to one particular case in which he said he didn't know where the trouble was, that perhaps the boy lied. Possibly he did, but I do not think any engineer is going to permit any useless waste in a boiler room if he can help it. I have never yet heard of one that did.

In regard to anthracite coal, some years ago there was established in the State of Pennsylvania a society for the investigation of waste fuels. This was under the charge of Mr. D. B. Coxe. I think that he laid down the rule very plainly at the centennial, when he said that the differences in heat valuations of coal one grade would develop as compared with another were considerable; he found that in a mechanical stoker some kinds of small coal would burn to clear ash without a clinker, and from another kind he would get the same result but a lower temperature; but if you mixed the two together they clinkered so badly that you could not do anything with it; which goes to show that while the chemical analysis may determine practically the same amount of free carbon, and practically the same amount of ash and the same amount of impurities, yet when you mix them they will not develop the same amount of heat in burning. That is all a matter of record.

Mr. Wilson referred in one place to a saving of $15,000 in fuel by a new arrangement of the furnaces in the State, War and Navy Department. I will ask Mr. Wilson if he can say what percentage of fuel burned that saving means.

Mr. H. M. Wilson: I couldn't tell you the exact percentage. They had been buying coal that cost considerably over five dollars a ton, furnace coal, I think; after the modification of their furnaces they were buying coal which cost about one dollar, buckwheat coal, high in ash.

Mr. E. M. Nichols: I have been through the same experience myself. He also spoke of low grades of coals where they only got twelve per cent ash; what was the efficiency of that coal as compared, pound by pound, with a higher grade of coal; and what was the low grade coal, was it fine small coal, or was it dirty coal?

Mr. H. M. Wilson: I am not able to answer that question in detail, for the simple reason that our tests on the combustion of that coal have not been figured up; we merely have the chemical analysis, which shows us what was the ash. We know we paid eighty-eight cents a ton for the coal, and the coal is as good coal as is necessary for the work it has to perform.

MR. E. M. NICHOLS: The term "low grade" coal as compared with the value of it is a misomer and misleading. I would like to ask one question in regard to the tests at Cleveland: I would like to ask Professor Bemis or Mr. Schulz, if they make any boiler tests to check up the calorimeter tests, so as to know whether or not they are in regular ratio? You spoke of this coal that only gave you 10,000 or 11,000 B.t.u. How did that check up with the analysis? Did you check up any of that coal by the regular boiler tests and compare with your chemical analysis?

MR. C. F. SCHULZ: Only two cars of that coal were received in six months, and of course that was mixed in with the other coal. No evaporative tests were made.

MR. E. M. NICHOLS: I am inclined to think that for the small consumer that Mr. Diven referred to, if you can arrange your boiler plant to test fuel at comparatively small cost and if your fireman or engineer is not thoroughly up to date give him a line of education—it doesn't take long to do those things—you will find that it will give you, so far as satisfying yourself is concerned anyhow, a line on the efficiency of the different fuels. It can be done often without any extra cost in labor. I have not found out yet, but I would like to know, of a long repeated line of chemical tests checked right up with boiler tests at the same time.

MR. W. S. CRAMER: You mean an evaporation test? I do not want you to think that I am fostering coal tests or the business of making contracts on heat unit basis but Secretary Diven invited me to write a paper on my experience of three years buying coal on evaporative tests. The recollection of my experience was so horrible that I didn't want to think of it at all. I went through with it three years and I will say to you that I don't advise any of you to attempt any such proposition as that, of carrying on daily evaporation tests, because such tests mean a perfect test or they amount to nothing. Anybody that has ever made a test of a boiler from beginning to end, doesn't want anything like that attached to their everyday work in a steam plant. I was bucked up against college professors and everybody else. I put in seven months out of every twelve on boiler tests and coal tests. I had to deal with a pretty good bunch of coal men that had money back of them. We were blazing a way and the other people were following in our footsteps. The chances are that they would have to meet the proposition, as the usual way to buy coal, and so they were after me good and strong. I stopped it after the third year; and have not gone into it since.

MR. EDWARD H. TAYLOR: There is one other point that I want to allude to. I think it may not apply to every gentleman here, but it is a matter that affects both small and large consumers in the buying of coal, particularly with a small consumer that burns from three thousand to five thousand tons a year. I refer to the tendency on the part of the coal man to pay the engineer five or ten cents rake-off for burning his particular coal, and the dealer charging it up to the consumer. I have had innumerable cases in which that question has come up, and it has been the cause of our business springing into existence. We have some twenty plants that we are operating, in which we get all kinds of results, and we have considerable trouble in ascertaining the reason for this, especially in regard to its affecting the cost per kilowatt. We commenced investigating, and when we found that the engineer was not get ing the results, we discharged the engineer, found an honest engineer and got the results. On tracing the matter up, we discovered that the engineers we let go had real estate and other property that they could not have become possessed of on the salaries they were receiving, because they were receiving but small wages. That opened our eyes, and it is one of the reasons why many companies buy the coal under the plans and methods set forth in the paper. I find the small consumer is the greatest victim. While the cost in money might not have been more than two or three cents a ton, yet in loss of heat units they were losing ten cents a ton in loss of efficiency in their boiler rooms

MR. S. B. FLAGG: The suggestion is made by Mr. Nichols that the operating engineer occasionally make boiler tests to determine whether or not the coal which is being delivered is uniform in quality and of the grade contracted for. This plan might work out very well as long as no complaints were made by the consumer, but in case of any controversy, the coal contractor would be very reluctant to accept as evidence, in support of any claims, the results of tests made by the regular operating engineers. In many cases the conditions under which these tests would be made are such that the error in results would equal or exceed the ordinary variation in the coal. It is possible, by handling the fire one way, to make the heat balance show more heat obtained from each pound of coal than it actually contained, or by different manipulation, to make the boiler and furnace show a very low efficiency. This being the case, the contractor will naturally want to satisfy himself that tests were made in such manner as to obviate the possibility of the errors mentioned.

In regard to the clinkering of coal. the point was brought out that one can not always predict from the composition of a given sample what the tendency of that coal to clinker will be. It is a very difficult matter to tell from the analysis alone exactly what amount or character of clinker will be formed.

The Geological Survey now has a number of samples of clinker taken during several boiler trials under different conditions of combustion, and in connection with the tests noted a study is to be made of the clinkers collected, with the hope that there may be obtained some additional information regarding the effect of certain ingredients upon clinker formation.

It is also to be noted that the way in which a furnace is operated has a very important bearing on the quantity of clinker. For instance, a coal may be burned at one rate of combustion with one furnace temperature and give no trouble, but at a higher rate of combustion and with a hotter furnace, the same coal may clinker badly. This was very clearly demonstrated recently to a man who claimed particular advantages for a certain type of furnace he had invented. According to his statement he was never troubled with clinkers, but the reason was that no attempt had been made to run the furnace at high temperatures. As soon as this man was done, the fireman was kept busy with hook and slice bar.

Mr. E. M. Nichols: Referring to Mr. Flagg's statement, that bears out the statement in regard to the calorific value, I have in mind one particular heating plant that was in operation for sixteen years and had never given the owner of the plant any trouble whatever, not a particle. On one occasion, however, I was sent for very hurriedly to come out to his house. He explained to me that he had had a larger fire than usual, he had been in the habit of putting firebricks along the wall to cut down his grate surface. He had taken out all these bricks and used more fuel and could not get up any steam. The fire did not look right to me, but he insisted so strongly that it was a better fire than he had ever had before that I said no more on that score. Finally I said to him, "Won't you try to get some other kind of coal?" He sent to a dealer in town and got another grade of coal and had no more trouble. The one kind of coal required a very much stronger draft in order to get the rate of combustion required to develop the heat. While I think that a chemical test is a good plan, I think it ought to be checked up with a boiler test.

Mr. S. J. Rosamond: Mr. Taylor made the statement that you should not try to influence the seller of coal to furnish a coal that he did not have, that is one of higher B.t.u. than his mine produced.

Now, we have a very important coal field around Fort Smith, and operated under some very unfortunate laws. I expect that Dr. Wilson knows about these laws under which we operate.

We have what is known as the no screen law, which requires the operator to pay the miner on a mine run basis. Under this law there is nothing to prevent the miner from using heavy charges of powder, thus badly shooting up the coal, mixing with it slate, rock and dirt, resulting in a low B.t.u. and a high percentage of ash.

We tried last winter to get this law repealed but failed. I want to ask Mr. Taylor if in buying coal under his present specification, that is on the B.t.u. basis, what changes would have to be made in the specifications to meet our condition.

I desire to warn Mr. Taylor and Dr. Wilson that I would like to have this answer in such a shape that it can be used to influence our legislature in giving us a law covering this matter that will result in giving us a coal from which we can get results that we know our grade of coal will give us if it is reasonably clean.

Mr. E. H. Taylor: The first point I believe that the gentleman from Arkansas should put up to the legislature is that he should endeavor to get them to define the term "mine run."

The greatest trouble we have at the present time is the lack of definitions for the various sizes of coal. I did not touch upon that in my paper except with regard to the screenings. I was trying to bring about something definite on the screening proposition.

Now regarding the "mine run" coal, which is their trouble in Arkansas, I had to testify in a law suit at Grand Rapids, Mich., between the Pittsburg Coal Company on one side and William Roach of Hart, Mich., on the other side. Mr. Roach had a pea cannery, the largest in the world. He does all of his business in a very few days or weeks, and along about the first of July he was running his plant full blast paying thousands of dollars for peas every day. He sterilizes all of his peas. The Pittsburg Coal Company agreed to furnish him Youghiogheny mine run coal. The coal did not keep the steam up, the peas were not sterilized properly, they went out on the road sour and were sent back, costing Mr. Roach $33,000. He did not pay for the coal. The Pittsburg Coal Company sued him for about $4000, the price of the coal. He burned two or three carloads, and left the rest on the track, and the railroad took them for freight. Mr. Roach kept samples of the coal. The case came up for trial, and the point that was at issue was whether it was Youghiogheny mine run. I analyzed the coal and found it contained twenty per cent ash. The Pittsburg Coal Company contended that mine run coal was anything that came out of the mine. I secured a face sample from the mine that shipped the coal and found that the sample analyzed seven per cent ash and two per cent extraneous matter. My testimony was that there could not be over nine per cent, and that no shipper ought to be allowed to ship mine run by taking anything out of the mine that not was fit to burn.

If you have a B.t.u. contract in force you will find that the coal men will all combine. They have a strong organization and they attach a bill-of-lading to the car when shipped. They make you pay for the coal as soon as you get it. They have the strongest organization of coal operators in the southwest territory of any part of the United States. In Oklahoma and Arkansas, and all the field through there, if you have a B.t.u. contract providing for a certain per cent of ash, you are all right if you get the coal dealer to sign that contract, and if he sends you more ash than the contract calls for the court will sustain you every time. There are a number of decisions they have there that will back that point up, that you cannot possibly deliver something out of your mine that is not coal. At first the judge wanted to know why I allowed two per cent? He said where the person has not better coal why not settle on the basis of seven per cent ash? I told him that in the process of mining they were unable to mine coal entirely clean, that there had to be some dirt, and on that account we had to make some allowance for the dirt; but that dirt in excessive quantity was entirely wrong. The court upheld me and decided in the favor of Mr. Roach, and awarded Mr. Roach damages. He filed a cross bill suing for $33,000; but he never got it. But he won out on that particular contention, which has benefited every other man, that is interested in the same way. If you have a B.t.u. contract you can make them deliver the proper percentage of ash, or reject the coal and not pay for it.

MR. S. BENT RUSSELL: The speaker has been greatly interested in Mr. Taylor's paper. It contains a great deal of valuable information, and his views are certainly pertinent and instructive.

The subject may be considered in two aspects; the first question in buying coal is, which is the best coal to buy? The second is how to insure the delivery of coal of the quality agreed upon.

Taking up the former, the question of determining the cheapest coal considering the quality, we will of course find that the heating power of the coal is the prime consideration. It sometimes happens, however, that we have coals from entirely different fields or markets brought in competition. It will then be hard to determine from any short time test the comparative merits for constant use.

This is true of a boiler test as well as of a test made in the laboratory. It follows that there will be cases where the coal that gives the most heat units for one cent will not give the greatest economy of operation in the long run. As a rule, if a coal has one-fourth more heating power than another, its value is more than one-fourth higher for boiler purposes. It would seem wise on the whole to begin with some caution in purchasing coal by the strict heat unit basis when the coals in question have not been used before in the plant.

Now as to the second aspect of the question, how much should be deducted for a coal that does not come up to the contract grade, i. e., does not furnish the B.t.u. specified in the contract? Should we make the deductions as provided in Mr. Taylor's specifications? Mr. Taylor stands on the basic principle that the purchaser should be protected from loss. If the coal falls in value, the purchaser should not lose. In other words, as Dr. Wilson says, "The purchaser should pay for what he gets." Now there is another side to the question. The object in view is to prevent the coal dealer from bidding on something different from what he will furnish. Would it not be fair if the dealer agreed to stand half the loss due to change in quality and to take half the gain when the quality exceeded the standard? Such an arrangement would mean less risk to the dealer and might therefore lead to fairer prices.

The speaker does not wish to be understood as opposing the heat value contracts but feels that every side of the matter should be presented to those who have steam coal to buy or to sell.

WATER SOFTENING OR PURIFICATION AND ITS SAVING

BY M. MILLER

[illegible] carried into the streams was small compared to the large amount now carried off the fresh soil after each working.

Mountain streams often contain so little scale-forming matter that the excessive amounts of dissolved oxygen or carbonic acid which they carry in solution may cause corrosion. Such instances are familiar to railroad companies operating in the Alleghany Mountains in Pennsylvania.

Peaty waters are found which contain corrosive vegetable acids. Such waters are most common through the Southern States. Corrosive waters containing free sulphuric acid and acid iron salts occur in all coal-producing districts, especially in those places where coal is washed preparatory to coke production.

Well waters containing magnesium chloride are corrosive unless they contain an excess of calcium carbonate; the same is also true of waters containing sodium chloride.

NOTE:—Considerable of the data obtained in connection with the paper on "Water Softening or Purification and its Saving" was extracted from the paper written by Mr. James O. Handy, Chief Chemist, Pittsburg Testing Laboratory, on "The Purification of Water for the Production of Steam," contained in the Transactions of the American Society of Civil Engineers, for the year 1904.

M. MILLER

WATER SOFTENING OR PURIFICATION AND ITS SAVING

BY M. MILLER

Water obtained for boiler use is usually impure, containing incrusting and non-incrusting solids. The continued use of impure or hard water in boilers reduces the life of the flues and fire-boxes, increases the cost of maintenance, cost of coal consumption, and in general reduces the efficiency of boilers.

With the tendency to and demand for high pressure of steam, the question of water for boiler use is becoming more serious as the streams or available water supplies continue to get harder owing to water sheds being more thickly settled and a larger percent of them being used for agricultural purposes. In former years the water sheds remaining undisturbed for years, the rainfall dissolved and carried into the streams the soluble matter, so, with the protection afforded by the natural sod, the percent of hardness carried into the streams was small compared to the large amount now carried off the fresh soil after each working.

Mountain streams often contain so little scale-forming matter that the excessive amounts of dissolved oxygen or carbonic acid which they carry in solution may cause corrosion. Such instances are familiar to railroad companies operating in the Alleghany Mountains in Pennsylvania.

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The more or less complete removal of scale-forming matter or the neutralization of corrosive substances which occur in boiler feed-water has been carried out by several methods in the United States.

These methods may be classified as follows

1.—MECHANICAL METHODS

These include feed-water heaters, scum-catchers and blow-off cocks.

2.—CHEMICAL METHODS

(*a*) Direct Method: The chemicals are placed in the boiler or run into it with the water supply.

(*b*) Indirect Method: The chemicals are fed into the water on its way to a storage tank which serves also for the completion of chemical reaction and for sedimentation.

(*c*) Intermittent Method: The chemical treatment is given alternately to the contents of two or more tanks, allowing enough time for the reaction and sedimentation to take place during periods of quiet. The clarified water is drawn off and pumped to storage tanks or to the places where it is used.

(*d*) Continuous Method: The chemical treatment is given automatically to the water as it enters the apparatus. The chemical reaction, sedimentation and clarification take place during the progress of the water through the apparatus.

CLASS 1.—MECHANICAL METHODS

Feed-water heaters remove more or less completely from water the carbonate of lime which it contains, but other and more important scale-forming substances are not affected and pass on into the boiler, from which it is impossible to remove them. Sulphate of lime, which forms a very hard scale, is not precipitated in the form of scale until a temperature of 302° F. is obtained, corresponding to about 60 pounds steam pressure, which heat is not obtained in a feed-water heater.

CLASS 2.—CHEMICAL METHODS

2a. Direct Method

This practice has been and is very general in the United States and the beneficial results obtained have been in exact relation to the judgment shown in selecting the chemicals and the care shown in carrying out the details of the treatment.

The purifying agents used directly in boilers include:

1. Soda ash,
2. Caustic soda,
3. Phosphate of soda (tri-sodium phosphate)
4. Tannin compounds,
5. Fluoride of soda,
6. Aluminate of soda.

Soda ash has been most widely employed. Used without discrimination, it is rarely beneficial; combined with regular blowing off of the sludge produced by chemical action, it is a measure of great economic importance.

The Soda-Ash System

Principle: "When waters are treated in the boiler with soda ash, the incrusting solids are changed to carbonates and precipitated as a soft sludge which is readily blown out, instead of coming down in a crystalline condition and adhering to the boiler."

For Each Grain per Gallon	Soda Ash per 1000 Gallons
Calcium carbonate	0 02
Magnesium carbonate	0.02
Calcium sulphate	0.10
Magnesium sulphate	0.13
Magnesium chloride	0.16

Sludge Removal. By means of blow-off cocks drawing from several parts of the boiler, sufficient sludge and alkali are removed so that the boiler can be continued in service a much longer time than would be possible otherwise. Some blowing off must be done when boiler is at work, but the greatest efficiency in sludge removal is secured if time for settling is allowed. About 4 per cent of water is blown out with the sludge.

Even in the worst district, the life and mileage of flues and fireboxes were more than doubled.

Treatment. Waters containing 25 grains of incrusting solids per gallon required not over 4 lb. of soda ash per 1000 gallons of water used.

The cost of heating the 4 per cent of water which was blown off was estimated at from 0.4 to 0.8 cent per 1000 gallons.

Thus the total expense for chemicals and for loss of heat due to blowing off would not exceed 4.8 cents per 1000 gallons.

Advantages of Direct Soda-Ash Treatment. Elimination of first cost and interest charges on softening machines or plants.

Limitations of Direct Soda-Ash Treatment. Boilers must be more frequently washed out, because blowing off does not completely remove sludge.

Foaming occurs frequently, due partly to suspended sludge and partly to the presence of carbonate of soda in variable excess in the water.

Very hard water cannot be treated sufficiently to prevent scale formation without introducing soda ash enough to cause foaming.

Conclusion. While the use of soda ash is a very useful temporary expedient directed toward scale prevention, all large steam users will eventually discard it in favor of methods which purify feed-water before it reaches the boiler.

2b. Indirect Method

Treatment of water by the introduction of chemicals into the water as it flows to the storage tank was the first step in the evolution from direct treatment toward complete softening machines. It was designed to avoid the first cost of softening machines by utilizing the existing storage tank for chemical reaction and sedimentation.

Several such plants exist in the United States and many have existed.

They have no feature to recommend them except low first cost.

2c. Intermittent Method

The devices described under this heading are intermittent in operation in that there is a pause of several hours after treatment. This is to give the time considered necessary for chemical reaction and sedimentation.

The general plan of operation is as follows:

Two or more tanks are provided, the aggregate capacity of which is usually four times the hourly output expected.

These may be of either wood or iron construction and may be placed on ground level or elevated on trestle-work according to whether repumping of softened water is to be allowed for or avoided.

The tanks are filled alternately to a certain level with hard water. In some plants the milk of lime is added during the filling and the agitator is run at the same time. In most of the plants the practice of dissolving the soda ash in the milk of lime and adding both together when the tank is filled is the one followed.

Agitation continues for 15 to 20 minutes, followed by a period of perfect rest, usually varying from one to two hours.

At the end of this time the softened water is drawn off in a proper manner to avoid the introduction of the precipitated solids to storage tanks from which it is repumped to a higher elevation if necessary or drawn direct from the treating tank.

2d. Continuous Method

The type of machine now referred to is the one which is so designed that the flow of water to the plant operates all necessary mechanism (stirrers, etc.).

The feed of chemicals is regulated by proportioning devices. Proper mixing of chemicals with hard water takes place automatically as the water passes through the machine; the chemical reaction is complete and sedimentation takes place. A filter at the top of the machine gives final clarification and the softened water is discharged without repumping into the storage tank.

Great advancement has been made in the results obtained by use of this method and the simplicity of the machine used.

THE ECONOMIC RESULTS OF WATER SOFTENING

The considerations which lead to the taking up of water softening by steam users may be grouped as follows:

First. Loss of service of boilers, due to impossibility of satisfactory, continuous operation with hard water.

Second. Possibility of substantial savings in fuel and repair bills and the checking of rapid deterioration of boilers.

The direct cost of water for boiler use is often but a small part of the expense in connection therewith.

The direct cost involves:

1. Cost of supply and pumping plant.
2. Cost of pumping.

The indirect cost involves expense due to:

1. Corrosion of boiler, tubes and fire-box by waters containing acids.
2. Incrusting due to presence of scale-forming material.
3. Interference with operation and incident danger due to engine failures from these causes and from boilers foaming.

The cost of water softening undertaken for the first reason is not always a matter of prime importance. It must be reasonable, of course, but results are the main thing. In most cases, however, water softening stands or falls by the relation of what it costs to what it accomplishes.

The charges against a water-softening installation are:

Interest on cost of plant.
Depreciation.
Chemicals for softening.
Attendance.
Power for operation (and repumping).

The credit items for a softener are:

Fuel saving.
Repair saving.
Depreciation saving.
Increased service obtainable from steam generators.

Cost of Softening Plants

The best softening plants cost from $4 to $5 per h. p. for installation up to 1000 h. p.; for 1000–2000 h. p. the cost is $4 to $3 per h. p. From 2000–5000 h. p. the cost is $3 to $2 per h. p. From 5000–15,000 h. p. the cost is $2 to $1.20 per h. p.

Depreciation

The above figures refer to steel construction. Plants for which wooden tanks are used are sometimes offered at as high rates, but the depreciation of wooden tanks under service conditions is much greater besides other disadvantages. If steel tanks are reasonably well cared for, 5 per cent is more than enough to allow for their depreciation.

Cost of Chemicals

The quantity of chemicals required for softening varies directly with the character of the water treated. The prices of lime and soda ash do not vary greatly in different sections of the country. There is, however, great choice in commercial lime, much of the building lime being so high in magnesia as to make it unfit or uneconomical to use. From 90 to 95 per cent lime can be had and should be insisted upon.

In my experience I have found it more economical to use hydrated lime, thus avoiding the objectionable features associated with lump lime, which are the grit and unburned limestone and the loss due to air slacking of the lime while in transit and while stored at the plant.

The cheapest waters to soften are those the hardness of which is due to carbonates of lime and magnesia only. Such waters require simply lime-water treatment. It costs only 0.2 cent per 1000 gal. to remove 1.42 lb. of carbonate of lime (equivalent to 10 gr. per gal.) and only 0.48 cent to remove the same quantity of carbonate of magnesia.

The amounts are sufficient to give a great deal of trouble in heaters and boilers.

The removal of sulphates and other soluble compounds of lime and magnesia from water requires the use of soda ash. It costs 1.20 cents per 1000 gal. to remove sulphate of lime equivalent to 10 gr. per U. S. gal. The same amount of sulphate of magnesia requires 1.36 lb. of soda ash, which costs 1.36 cents per 1000 gal.

Attendance

The cost of attendance at softening plants varies greatly, but is never more than that of the time of one man (or boy). It is often much less. The most common arrangement is for the engineer or pumper to look after the softening plant.

With the best type of plants two or three hours per day are all that are required for attendance unless the installation is very large.

Chemical tests for control of the softening plant can be carried out by persons of average intelligence.

POWER FOR OPERATION

The most satisfactory plants are those where the power for mixing and pumping the chemicals is gotten from the flow of water to the softening plant, so arranged that the flow of the water starts all stirrers, or other mechanism, and the filter, as it becomes dirty, changes the direction of the flow of water, automatically changing the valves allowing the treated and filtered water to be drawn from the storage tank through the filter, washing the sand and discharging the sludge through sludge pipes into sewers. The tilting buckets can be so arranged as to give the desired amount of water to wash the filter when it will, by counter weights, be carried back to its normal position.

The advantage of this plant is that it is automatic and requires less attention on the part of the operator. The plant was designed for railroad water supply, but what holds good for railroad water supply will be equal for any steam boiler.

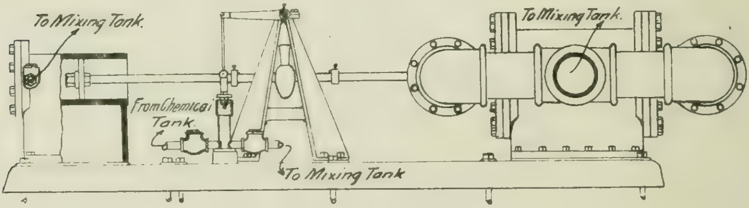

FIG. 1. MEASURING MOTOR.

The best plants have all stirrers or other mechanism actuated by water power. The flow of water to be softened starts everything, and the water is softened at a sufficient elevation to run by gravity to the place where it is to be used.

FUEL SAVING

The earliest recorded researches on the subject of loss of heat caused by boiler incrustation are those of John Graham, conducted in 1850 to 1857 and published in Memoirs of the Literary and Philosophic Society of Manchester in 1860. He says: "A scale of sulphate of lime $\frac{1}{16}$ in. thick reduced the efficiency 14.7 per cent."

Dr. J. C. Rogers states that a scale $\frac{1}{16}$ in. thick makes 15 per cent more fuel necessary than with clean heating surfaces.

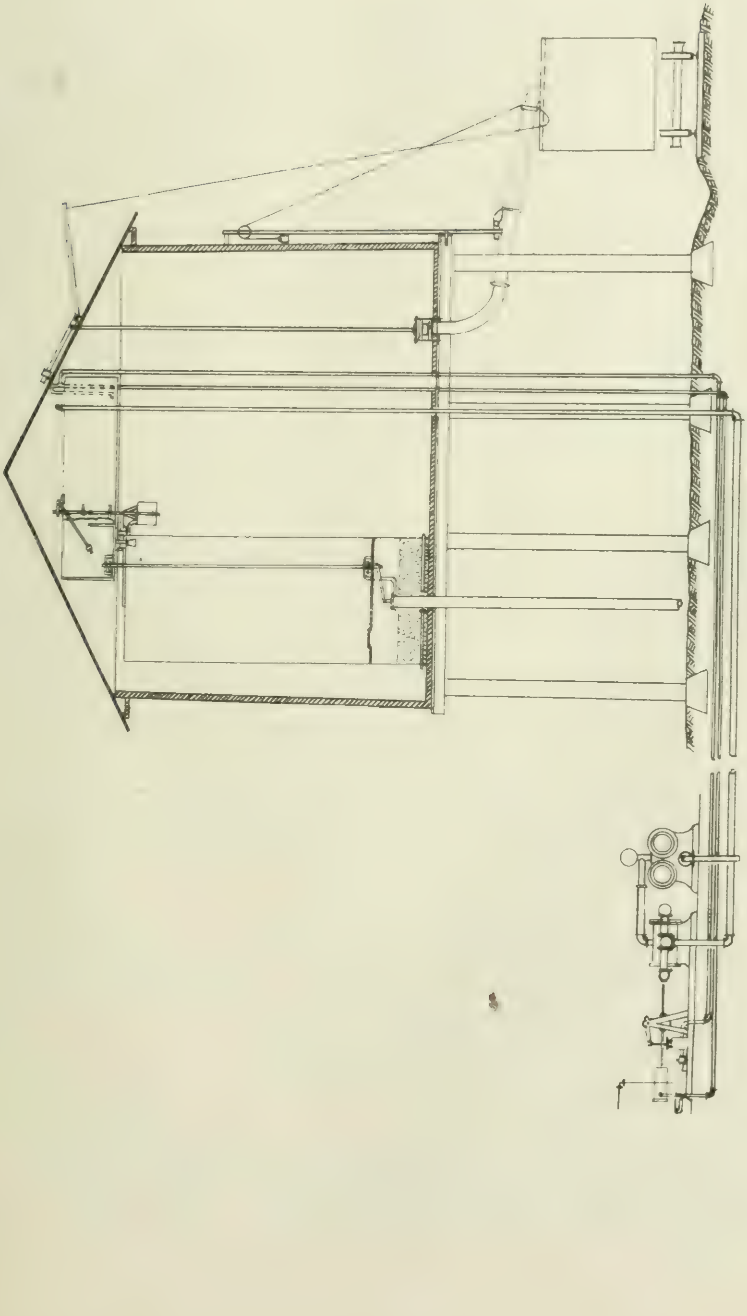

FIG. 2. WATER SOFTENING PLANT IN CONNECTION WITH A RAILROAD WATER TANK.

Rankin states that it is estimated that $\frac{1}{16}$ in. of scale requires the use of 16 per cent more fuel.

Reuben Wells ran two engines for several months with heating surfaces covered with scale and an equal length of time later with clean heating surfaces and found a fuel saving of 17.5 per cent. Details of scale thickness or density are not given.

These records would seem to be sufficiently convincing and yet they are sometimes questioned as if they were theoretical calculations instead of actual results.

FUEL SAVING ON RAILROADS

Three railroads, the Union Pacific Ry., Chicago & Northwestern and the Pittsburgh & Lake Erie R. R. Co., have installed a large enough number of softening plants to warrant the expectation of definite results showing fuel economy, etc.

Of these only the Union Pacific Ry. has given out preliminary results. They report 7½ per cent increase in gross ton-miles per pound of coal. This is believed to represent the effect on boiler conditions of 10 softening plants on the Nebraska Division and is really not a comparison between steam raising with clean tubes and the same with scaled ones.

Better results are sure to be obtained. Even as they are, they lend additional evidence to an already certain matter.

BOILER REPAIR SAVING

Estimates. For C., B. & Q. Ry. Co. engines operating in Illinois and the hard-water districts of the Middle West, Wickhorst estimates that boiler repairs cost $1200 per locomotive per year, and that softening should reduce this at least 25 per cent.

The engineering department of the P. & L. E. R. R. Co., having moderately hard waters to deal with, estimate that with water softening a saving of at least $100 per locomotive per year will be realized from boiler repair saving.

Actual Results. Returns from railroads, etc., having water softeners in operation give results which exceed the above estimates.

The C. M. & St. P. Ry. Co. reported in 1899 that Smith's soda-ash treatment of boiler water has made possible an annual saving of $75,000 in boilermakers' pay roll.

The Union Pacific Ry. Co. report as a result of water softening 34 per cent decrease in boiler repairs per engine-mile.

The C. & N. W. Ry. Co. report 40 per cent decrease in boilermakers' force required for repairs on their Iowa Division during

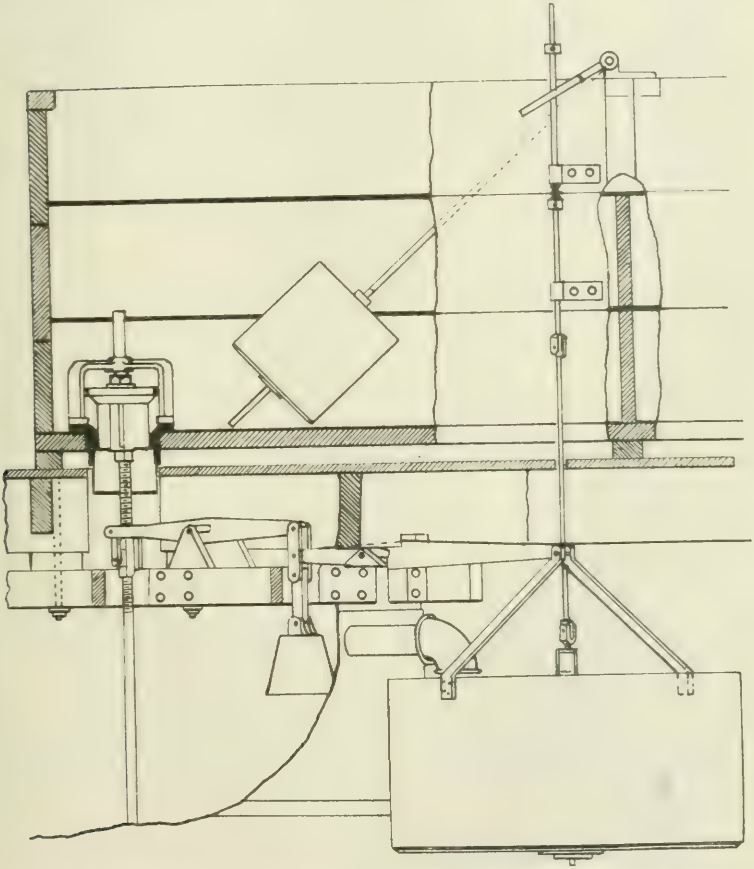

FIG. 3. UPPER SECTION OF TREATING TANK SHOWING APPARATUS FOR AUTOMATICALLY WASHING FILTER.

the last six months of 1903 as compared with the corresponding period in 1902.

On the Missouri Division of the St. Louis, Iron Mountain & Southen Ry. Co., in 1906 three water-softening plants were installed at an actual cost of $12,500, which made an actual saving of $12,245 in boiler makers' salaries, handling an increased tonnage of 15 per cent. reducing engine failures 97 per cent with a decrease in number of engines.

On the Colorado Division of the Missouri Pacific Ry. Co. the installation of four treating plants out of 19 water stations, decreased the cost of boiler makers' salaries in one year $8800, handling an increased business of 14 per cent with 5 per cent less engines.

These records show that in all cases where water contains over 10 gr. of scale-forming ingredients, by treating the water the life of flues and fire-boxes is increased 100 per cent. With 20 gr. the increased life of flues and fire-boxes with treated water is 200 per cent.

At the Missouri Pacific shops at Kansas City, Mo., we have three boilers in use, one 150 h.p., one 80 h.p. and one 45 h.p. Previous to 1905 flues had to be changed in these boilers every six months. In 1906 we put into use a water softening plant and renewed the flues in all of the boilers and they have been in use ever since and show no signs of leaking at the present time after 3 years' use of softened water.

During the month of December, 1905, we pumped 8,220,000 gallons of water; and in the month of December, 1908, 12,460,000 gallons of water, with a saving of 20 per cent in fuel over that used in December, 1905.

About the same ratio of saving is shown on switch engines working in this yard where they get nothing but softened water. Following is the mineral analysis of the water at this point:

	Gr.
Carbonate of lime	16.79
Carbonate of magnesia	3.42
Sulphate of lime	0.75
Sulphate of magnesia	2.06
Oxides of iron and aluminum	0.12
Silica	1.91
Alkali chlorides	0.88
Alkali sulphates	0.29
Organic matter, etc	0.82
Total solids	27.04

Total incrusting solids 25.05 grains per U. S. gal., or 3.58 lb. per 1000 gal. Total non-incrusting solids 1.99 gr. per U. S. gal., or 0.28 lb. per 1000 gal.

Depreciation of Boiler Plant

It is difficult to put into dollars and cents exactly what water softening means in prolonging the life of boilers. The wear and tear on boilers using softened water would certainly average 75 per cent less than with untreated water.

The Union Pacific Ry. Co. now finds a set of flues lasting two and one-half years, where formerly six months to a year was the limit.

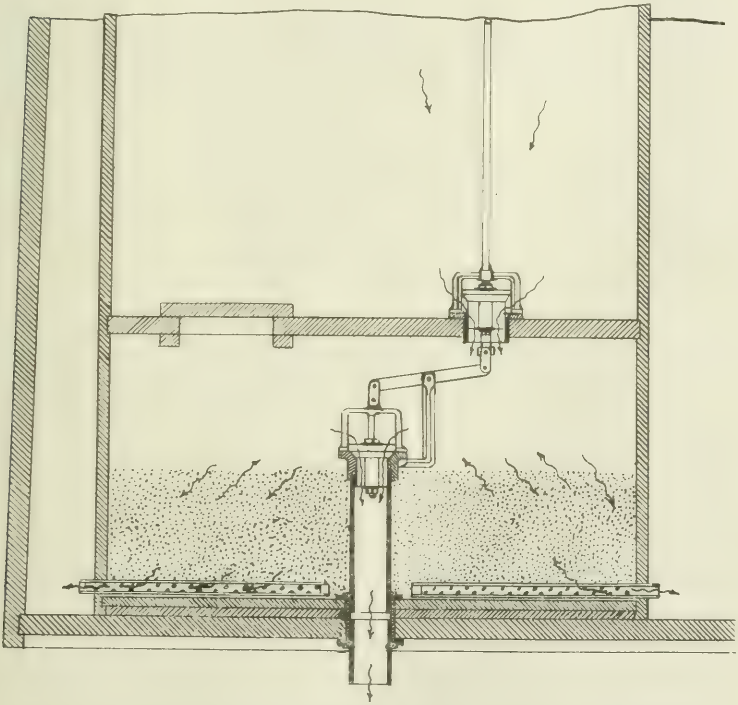

FIG. 4. LOWER SECTION OF TREATING TANK SHOWING ARRANGEMENT OF FILTER.

Washing out Boilers

A marked decrease in this item is noticed by users of water-softening plants.

While the accumulation of soda salts necessitates water-changing by blowing off quite frequently, yet complete washing out for the removal of sludge and scale is much less frequently required than formerly.

Increased Service from Locomotives

When locomotives are in the round-house or shop, their owners are losing; the same would be true of any commercial plant where steam boilers are used.

1. Interest and depreciation.
2. Their entire earning capacity.

Instances are known in industrial plants where water softening has made so much more boiler horse-power constantly available that contemplated extensions of plants have become unnecessary.

It is already evident that the financial benefits derived from the adoption of water softening far outweigh the expense.

Chemical Control of Softening Plants

Skilled supervision is not necessary after the operator has learned to make tests for hardness, alkalinity and excess of lime.

Hardness is determined by the soap test, alkalinity or acidity by titration, with standard acid or alkali. The silver nitrate test is used for detecting excess of lime.

By use of tables the operator is able to change the treatment to suit the conditions shown by his tests.

Professor L. P. Breckinridge of the University of Illinois, as a result of careful tests of the effect of scale on rate of evaporation in a locomotive boiler, showed the loss due to scale from $\frac{1}{32}$ to $\frac{3}{64}$ inch in thickness to be 9.55 per cent as compared with the results from the same engine after cleaning the boiler and putting in new flues.

It is assumed that the loss is indirectly in proportion to the thickness of the scale.

Assuming $\frac{1}{32}$ in. formation in 6 months, which would be produced by a very fair quality of water, 10 grains of incrusting solids and a loss of 9 per cent in evaporation due to scale of this thickness, we have

MONTHS BOILER OPERATED WITHOUT CLEANING	LOSS OF EVAPORATIVE EFFICIENCY AT END OF PERIOD. PER CENT	AVERAGE LOSS OF EVAPORATIVE EFFICIENCY FOR PERIOD. PER CENT
2	3	1.5
4	6	3.0
6	9	4.5
8	12	6.0
10	15	7.5
12	18	9.0

Loss of evaporative efficiency means increased coal consumption. Assuming the normal consumption of an engine per year as 3000 tons at $2 per ton, equals $6000 and 5,000,000 gallons as the normal water evaporation, gives

MONTHS BOILER OPERATED WITHOUT CLEANING	AVERAGE LOSS OF EVAPORATIVE EFFICIENCY FOR PERIOD. PER CENT	COST OF INCREASED COAL CONSUMPTION PER ENGINE PER YEAR.	COST OF INCREASED COAL CONSUMPTION PER 1000 GAL. OF WATER EVAPORATED
2	1.5	$ 90.00	1.8 cents
4	3.0	180.00	3.6 "
6	4.5	270.00	5.4 "
8	6.0	360.00	7.2 "
10	7.5	450.00	9.0 "
12	9.0	540.00	10.8 "

The cost of washing locomotive boilers may be assumed roughly as from 60 cents to $1.20 per boiler washed, averaging say $1, and the saving due to reducing the frequency of washing from each 20 days to each six months would be about $20 per year, or 0.4 cent per 1000 gallons of water used.

The cost of removing, cleaning and replacing boiler tubes per set can be placed at $110. The difference in life with good and with bad water may be taken roughly at 24 months for good water and 6 months for poor water used. While these figures are mostly from a railroad saving, the same would hold good in the boiler-room.

WATER SUPPLY AND TREATMENT FOR POWER PLANT PURPOSES

WILLIAM MILLER BOOTH

The price of raw material, of fuel, labor conditions and freight rates are important factors to be considered when a new industrial plant is to be built. Less often investigated, yet of primary importance is the presence of a constant supply of good water. If possible two independent sources should be made available.

It is not a large manufacturing concern that requires boilers of 1000 h.p. capacity. If run 10 hours per day these evaporate approximately 170 tons of water. When condensing engines or turbines are used, from 14 to 17 times as much water is necessary to return the steam again to its original state, or about 2500 additional tons,—in the aggregate more than 9000 pounds per minute.

The quality of the water is not a matter of indifference as modern power house apparatus makes exacting demands of the medium passing through and over its parts. It will readily be seen that choice of water requires knowledge of power plant conditions and should not be handled in a haphazard way.

While our population and manufacturing interests constantly increase, available water is decreasing, especially in our small streams that flow through densely settled districts.

Given two sources, the use of that which entails the least cost is naturally considered,—the quality is often neglected. Unfortunately water exactly adapted to boiler use is seldom found in nature.

For convenience we classify waters as follows:

The first group includes rain and snow waters that are free from scale-forming materials, but which contain organic matter and in the first instance may have a strong acid reaction. The use of such waters is attended with danger from pitting. Harder water should always be mixed with these, or a slight excess of alkali may be added.

Precipitated waters flowing over granitic rocks are ideal for boiler use, as enough alkali is absorbed to prevent pitting. Water from wells in the Adirondacks, driven in granite and quartz sand to a depth of sixty feet, was found to possess a hardness varying from .5 to 2 degrees Clark,—pure water being unity.

The only distilled water practicable for boiler purposes is that returned from vacuum pans, pumps, engines, turbines, surface condensers and heating systems. Condensed water from turbines containing no oil ought to be ideal for boiler use. We have,

Available Supplies

CLASS.	SOURCE.	CONTAIN.	ACTION IN BOILERS.
Soft.......	Rain and Snow	Ammonia Salts	Corrosive
	Water from granite and quartz rock	Alkali	Negative
	Returned	Ammonia	Corrode
	Swamps	Organic matter	Corrode
	Lakes Large rivers	Calcium and Magnesium Salts	Slight scale
Hard.....	Springs	Lime, magnesia, iron	Scale forming
	Lakes	Sulphates	
	Small Rivers & Creeks	Chlorides	
	Wells	Carbonates	
Saline....	Sea Well Mineral Springs	Lime, magnesia, Sulphates, Chlorides & Carbonates, Sodium & Potassium	Scale forming Corrosive Foam
Alkaline...	Streams from Western Plains Springs	Sodium, Chlorides, Sulphates and carbonates, Silica, Lime, Magnesia.	Foam
Acid......	Mineral Springs Wells Coal Regions.......	Hydrogen Sulphide Iron Sulphate Sulphuric acid	Corrode

however, had an instance of severe corrosion resulting from the use of such water with a proportion of fresh hard water added at each return to the boilers. Returned turbine water should be made slightly alkaline. We believe that the open heater and hot well should be much more generally used and that a good oil separator is indispensable in any large plant. Anxious to keep his apparatus well lubricated the engineer often uses an excess of oil which makes it difficult to utilize the condensed water. A large amount of energy escapes daily from many plants through heated water that runs to waste, in addition to the loss of soft, scale-free boiler water. Many engineers suffer from oil at the surface of the water in the boiler; the gauge glass showing this condition quickly. If mineral oil is used in the power plant we do not worry about the presence of a small quantity in the boiler, but prefer to keep it out.

Another class of soft waters is found in the lowlands of the coast. A heavy rainfall with finely divided organic matter and heat, combine to charge standing water with organic matter which may be acid in character. Boilers using such water suffer from corrosion and require alkali.

The waters of some lakes, large rivers and a few deep wells deposit little scale and may be termed "soft." Arbitrarily we fix the hardness under 3° Clark. Such waters contain suspended particles, sand, clay, leaves and dissolved organic matter, the quantity of these varying greatly during different seasons. These require considerable blowing down at the boiler. Water of this character is improved by sedimentation in large tanks followed by upward filtration through coarse material, as sand, coke breese or excelsior.

We insist that water for boiler purposes shall be clean. Sewage laden lake or river water carries grease which accumulates upon the headers of water tube boilers and corrodes the tubes and shells of tubular boilers. Our clients are much annoyed by such water. We recommend sedimentation, upward filtration and legal proceedings against the corporation or individual contaminating the stream. This applies particularly to abattoirs, rendering plants, woolen mills and cities. As a last resort we recommend chemical precipitation and filtration.

HARD WATERS

A large proportion of our water supply is scale forming. If ten grains of this material per gallon are present nearly 140 pounds of sludge and scale will concentrate, in a 24-hour, 1000 h.p. plant. This badly interferes with the operation of the boiler as a steam producer. In many samples of water, carbonates vary from 3 to 15 grains per gallon and sulphates from a trace to 120 grains per gallon. What these compounds are and how they are formed will not be discussed here.

Organically pure but hard sources of supply are used by many cities and towns to the disadvantage of manufacturers. We have suggested in a previous paper that large operators should combine to manufacture soft water for their common use. Water companies might soften supplies furnished certain districts. We believe that scale-free, clean water is worth ten cents per 1000 gallons. It usually costs less than three cents to soften this.

Many manufacturers drill deep wells to provide drinking water and to serve as an auxiliary supply. We suggest consultation with a practical geologist before putting a large amount of money into such an enterprise.

Having been fortunate enough to obtain water this may be of any class mentioned in the table. For power plant purposes heavily charged mineral waters are to be avoided. We present an analysis of a well water that is useless for boiler purposes:

Grains per U. S. Gallon

Combined

Sodium chloride	1.252
Calcium carbonate	16.959
Calcium sulphate	87.462
Magnesium carbonate	.000
Magnesium sulphate	15.555
Magnesium chloride	.009

Calcium and magnesium carbonates and calcium sulphate are scale producers. Chloride of magnesium corrodes metal and sodium chloride accumulates on all semi-heated surfaces. For boiler purposes we have not been troubled by the precipitation of iron found in natural waters. If water from a well contains all of these forms of impurity in any considerable quantity it should not be used for power purposes.

Those who drill wells should take samples of the strata and water encountered. Analysis of these will show what veins of the supply are to be avoided and cased out. As an example of the vicissitudes of well drilling we instance the following:

To 100 ft.—small quantity, soft water.
100 to 600 ft. no water.
At 600 ft. salt; 300 grains per gallon, sodium, magnesium and calcium chlorides, with carbonates and sulphates.
At 900 ft. salt.
900 to 1200 ft. no water.
1270 ft. granite rock, no water; drilling suspended.

SALINE WATERS

Few waters are free from chlorides. Common salt is not considered scale forming, although large quantities are not easily handled, while the chlorides of calcium and magnesium are very objectionable in a boiler. We have found no trace of chlorine in an Adirondack camp supply drawn from a small stream. Water from Oneida Lake, N. Y., did not contain one part of chlorine per million. This lake is 28 miles long and several miles broad. The sample was taken through the ice in the winter.

Wells, springs and streams in the Salina group contain chlorides varying in our experience from traces—to 600 grains of salt per gallon. The quantity of chlorine at various localities in central New York westward is as follows:

Canajoharie, 570 ft. under surface	6 grains
Utica, 600 ft. under surface	300 grains
Oneida, 100 ft. under surface	30 grains
Syracuse, 50 ft. under surface	360 grains
Cayuga Lake	2 grains
Seneca Lake	2 grains
Akron, Ohio, 60 ft. under surface	2 grains

Waters in this belt contain also sulphates and carbonates of calcium, magnesium and sodium, the water varying in hardness from 5° to 80° Clark. Such water is found in Ohio, Ontario, Indiana and Michigan. These ground waters generally need treatment. Shale waters if in higher altitudes are very good with an average hardness of 6° Clark.

We have no remedy to offer for heavily charged saline waters. Evaporation results in choking boilers and condensers. Wells on opposite sides of the New York Central tracks at Oneida, N. Y., about 150 feet apart contain respectively 9 and 30 grains of salt per gallon, the first being 96 feet, the second 106 feet in depth. Both waters are used successfully, the first without, the second with softening apparatus. Well water containing one and one-half ounces of salt per gallon and scale forming cannot be used by Syracuse manufacturers to good advantage.

ALKALINE WATERS

Some waters contain carbonate, chloride and sulphate of soda and potash with perhaps chlorides of calcium and magnesium. This is particularly true of waters of the western plains and lakes. As an extreme instance we submit the following analysis of a water sent us from a California lake:

	Grains per U. S. Gallon
Silica	14.35
Alumina	trace
Oxide of iron	.00
Calcium carbonate	trace
Magnesium carbonate	.00
Potassium chloride	93.56
Sodium chloride	2754.30
Sodium sulphate	610.50
Sodium carbonate	2573.10
Acid carbonate of soda	248.50

This is a representative of very bad alkali water, which could not be used for technical purposes.

Our practical experience with alkaline waters has been confined to those artificially produced in Eastern plants by the softening process. If a boiler is clean we find it almost impossible by adding alkali to produce foaming. This has been proved with an excess of soda ash amounting to 50 grains per gallon.

ACID WATERS

Water from expensive wells sometimes tastes and smells of hydrogen sulphide. If at all strong engineers will usually not allow such water in their boilers. We believe that, should circumstances warrant the outlay, a heavily charged sulphur water could be successfully prepared for boiler or other industrial use.

Water from the mining districts often contains sulphate of iron. We consider this dangerous water and suggest treatment before use.

Some waters contain free sulphuric acid. Sometimes such water is supplied naturally but generally this is found in sludge from acid plants, coal washers, or refineries. No more dangerous material can find its way into the boiler.

A sample of scale from boilers in a Pennsylvania steel works was practically pure oxide of iron, the result of an acid supply.

We devote the remainder of this article to methods of handling scale-forming, saline, and alkaline waters.

Three principal uses of boilers afford a natural division as follows: marine, locomotive, stationary.

Marine boilers are generally supplied on coast-wise steamers, tugs and harbor craft, with soft water that is obtained at one of the ports at which the vessel touches. As many of the engine cylinders are run without oil the returned water is used again. Trans-Atlantic steam ships are supplied with surface condensers and complete distilling outfits of expensive design and the softened water is used again.

Locomotive boilers represent an enormous horse power and need the best water obtainable. Hard water only can be found on many lines. Sometimes a soft supply is found at one end of a division and hard water at the other. Alternate use keeps the boiler free from scale. Starting and stopping and generally in motion, the alkaline content of a locomotive boiler water must be kept low. With sludge, serious foaming may result through the use of an excess of softening agent. This subject demands immediate attention on the part of all railroads. Western systems have done more in this respect than those in the East.

Our experience with stationary boilers has been divided between shell and water tube types. Methods of water treatment apply in a general way to either, although many disadvantages of hard and muddy water are overcome in water tube boilers.

Engineers in charge of steam plants are usually ignorant of the principles of water purification. This is only partially their fault, as literature for their education has only recently been available. There are many plants the boilers of which cannot be operated a single week without a deposit of scale serious in character and quantity. The most easily procured remedy has been the "compound" furnished at an inflated cost. The introduction of the softening plant has widely advertised the fact that lime, soda ash, caustic soda and tri-sodium phosphate are cheap and efficient scale removers. Many an engineer spends the Sabbath day hammering scale only to repeat the operation the Sunday following. This is usually unnecessary, as proper chemical treatment will remove the scale formed and prevent the deposit of more.

The actual cost during the past seven months to keep boilers clean in a 2000-h.p., 24-hour plant has been less than $15, the hardness of the water being 5° Clark. Caustic soda and soda ash have been used in slight excess

Ideal conditions favor the installation of a standard softening system. We feel, however, that prejudice is so great that it will take at least five years to make these plants popular with engineers who have in many instances received gratuities from compound salesmen, or with managers who cannot see an adequate return for the investment.

We now turn to methods of treatment.

While waiting for a better understanding of the correct thing to do when annoyed by hard water we have adopted the following method which is now used in many plants. Analysis is made of the water supply or supplies; of the water from the heater, from each boiler and from the hot well. In this way we find remarkable conditions. The hardest water that has come to our notice was taken from three water tube boilers:

1. 43° Clark.
2. 85° Clark.
3. 382° Clark.

It is not unusual to find alkalies and scale-forming ingredients concentrated in the boiler water. If the supply has a hardness of 10° Clark, the internal water may have a hardness of twenty, thirty or even forty degrees.

Great stress has been laid on the removal of carbonates by heaters. We find carbonates in most boiler waters and believe that the best heaters may remove 50 to 75 per cent of these. The water circulates too rapidly to favor their deposit and the dissolved gases are occluded under pressure. We present the analysis of samples of water where a live steam purifyer is used. (Table 8.) The concentration of chemical salts in the presence of organic matter may cause serious corrosion. We believe that sulphates of calcium and magnesium may produce or aid in producing the holes that are eaten in feed pipes and flues, heretofore credited to chloride of magnesium but which we find may occur when none of this chemical is present. Further investigation must be made to determine the exact cause of the foregoing results.

Having proved the presence of concentrated salts in a set of boilers, we suggest to the engineer that he shall "blow down" once in four hours or two or three times per day from one-half to two inches of water. This form of treatment some engineers will not adopt, stating that it will strain their boilers to blow them under full steam pressure; others do this regularly. We have a plant of this kind in mind where there are two 200-h.p. shell boilers that have been blown down under full head of steam perhaps two inches each afternoon for four years with no injurious results.

The scale-forming materials separate in the boiler, the decomposing carbonates rising to the top and forming a light scum, which accumulates on the upper tubes, while the sulphates and precipitating carbonates form a dense, heavy scale on the shell and lower tubes of the boiler. We believe that it is a very good plan to blow out the accumulated sediment in the morning and in the evening, and that considerable scale may be removed from the water surface while the boiler is under full steam pressure, by opening suitable cocks.

Boilers are set in peculiar ways either accidentally or through ignorance. We have found boilers with the blow-off at the rear no less than 4 inches higher than the floor of the boiler at the front. In some boilers the blow-off is found 3 or 4 inches above the lowest point of the shell, and we find engineers who blow their boilers but once per week, putting in from one to five gallons of compound Monday morning, and making this last the entire week, blowing it out at the close of the working day Saturday. Severe scaling or severe corrosion may result from the lack of use of the blow-off valves. If we were running a boiler or a battery of boilers using hard water we would use the blow-off at least three times during the 24 hours. Lack of attention regarding falling scale and accumulating sludge may result in a bad bag or blister of the crown sheet.

THE PRESCRIPTION

If the engineer finds that he cannot handle the sludge through the blow-off valve, (and this the chemist can determine usually in advance,) a mixture of alkali should be used in the boiler. This is added with the feed water drop by drop. The quantity bears but little relation to that prescribed for the same water in a water softening outfit. For instance, the prescription may call for five pounds of soda ash and two pounds of caustic soda per thousand gallons of raw water. If this is placed in the boiler in exact proportion to the number of thousand gallons used the chances are that very severe foaming will result during the coming three days. We prefer to divide the prescription by at least five and then test samples of water taken from the boilers under treatment, making a careful analysis of such treated water. In this way we are able to determine the quantity and amount of chemicals absorbed and those left in solution, also the quantity and amount of scaling material removed, and that left in the water.

The scale that accumulates on the tubes and shell is often useful in determining the kind of treatment that a boiler needs, but this scale may differ materially in composition at different points in the boiler.

The use of boiler compounds containing tannin is determined by black scale which is a dye formed by the union of tannin and iron at the expense of the boiler itself. We discourage the use of such compounds.

Objections are raised by some engineers to the use of soda ash in boilers. We have yet to find a single instance where soda ash is used in moderate quantities—even to 50 grains per gallon in excess—has injured a boiler shell or tubes, and would much prefer the use of a small quantity of this material in a boiler water to the use of rain or distilled water, both of which have a highly corrosive effect on iron. Again, some engineers state that soda ash injures gaskets.

During two seasons we have tried this out in a 2000 h.p. plant where the steam is used for heating houses and office buildings, and although expensive and complicated steam traps, meters, and gaskets are used throughout the system, we have failed to experience any difficulty whatever from this method of treatment.

Having reckoned the amount of caustic lime required to remove carbonates from the water for internal treatment we use a fraction of its equivalent of caustic soda. With carbonic acid this material is changed to sodium carbonate and if sulphates are present a second reaction takes place. A much smaller proportion of soda ash is required than when lime and soda ash are used.

On account of this double action, we believe that caustic soda should be used much more generally in water, as it is more easily handled than lime and as, further, a concentrated solution can be made. After the preparation has been applied and an analysis of the water has been made, it is not difficult to see what changes are necessary. These should be applied at once. Any form of exact treatment for boiler water within or without the boiler, demands the services of an experienced chemist and an interested engineer. An excellent water softening apparatus failed because the engineer in charge would not give it fair treatment.

Those in charge of power plants are usually anxious to learn some of the principles involved in water purification. It has been our practice to supply a regular outfit for their use. This includes the following:

1 Glass burette,—funnel and filter papers.
1 bottle phenolphthalein solution.
1 bottle methyl orange solution.
1 bottle silver nitrate solution.

1 quart of soap solution with the formula for making up more, and sometimes a bottle of standard decinormal hydrochloric acid. This apparatus is purchased by the power plant owner, and placed in the engine room. We have been told by one engineer that he would not take one hundred dollars for the little kit of tools provided to determine the processes going on in the boiler water. The number of tests that these men will make and the care and accuracy exercised in making them are surpris-

ing. We have gotten up a printed form for permanent records, such being turned in at the office each day.

WATER SOFTENING PLANTS

As there are now several forms of water softening apparatus on the market that are entirely efficient the power plant manager and operator have no excuse for using a scale-charged water. With a thousand horse-power or a larger plant and with water about 10° in hardness a water softening outfit can be shown to be an investment paying more than 10 per cent on its cost and operating expenses. In some instances this percentage may be raised to a point where the whole apparatus will pay for itself within two or three years. There is great prejudice on the part of engineers to the use of softened water, and we have found men who have put in expensive plants of this sort who are not operating them. The reason being that "they're too much bother."

Considering the cost of extra fuel, flues, the cost of opening the boilers, removing scale and poor steaming capacity a scale-free water is a valuable investment. We find plants that are operating with boilers that have not been opened for months, and that are found in a scale-free condition, the water being of a hardness of about 20° Clark. per U. S. gallon. Originally we were not sure of the action of caustic lime and soda ash on concrete tanks, but believe that with a carefully constructed tank of this kind no danger whatever will result through the action of the alkali on the cement mass. A tank has been in use for this purpose for three years and is still in first-class condition.

The ideal chemical for softening water is not now available. Calcium, magnesium and the sulphate radical should be removed. Excessive foaming would be avoided and softened water would approximate distilled water in purity.

SUMMARY

In conclusion we wish to call attention to the following:

To locate at least one constant supply of good boiler water is an important duty of the engineer who lays out a new plant—if more than one supply can be made available every reasonable effort should be made to secure the second.

Water for boiler purposes should be clean and scale-free. Filtration and softening will produce both conditions even though the supply is bad, sodium chloride and alkaline waters excepted.

Money put into a "well" enterprise is a business venture with uncertain results, but is recommended if conditions warrant the expense.

Water companies should give technical aid to large power users if difficulty is experienced with the water furnished; that delivered to manufacturing districts might be softened before distribution.

Resident engineers should be compelled to make daily reports of the condition of the water from their boilers and a competent chemist should be employed in connection with every large power plant.

This association could to good advantage appoint a committee to report on technical methods of water analysis with the official adoption of a provisional method to be used throughout the United States. This branch of practical chemistry is now of great importance to mechanical engineers.

VARIOUS TYPES OF WATERS

No. 1.—Artesian well; useless for any commercial purpose, found 600 ft. under the surface in central New York.

	Grains per U. S. Gallon
Calcium carbonate	9.373
Calcium sulphate	.543
Calcium chloride	39.302
Nitrogen pentoxide	.000
Magnesium carbonate	.930
Magnesium sulphate	.000
Magnesium chloride	32.333
Sodium chloride	293.350
Oxides of iron and aluminum	.542
Silica	.600
Total solids	376.975

No. 2.—A well water in the salt belt containing oil. Has not been used successfully in a tubular boiler.

	Grains per U. S. Gallon
Calcium carbonate	12.48
Magnesium carbonate	.00
Calcium sulphate	4.59
Magnesium sulphate	.00
Magnesium chloride	5.18
Sodium chloride	32.49
Oxides of iron and aluminum	.025
Silica	.23
Nitrogen pentoxide	.29
Organic and mineral oil	9.64
Total solids	64.92

No. 3.—Water that produces a very hard scale that is very corrosive, eating out feed pipes in a few months.

	Grains per U. S. Gallon
Sodium chloride	1.76
Calcium sulphate	23.45
Calcium carbonate	8.94
Magnesium sulphate	11.00
Total	45.15

No. 4.—A very corrosive water, scaling also.

	Grains per U. S. Gallon
Calcium carbonate	6.140
Calcium sulphate	77.543
Magnesium carbonate	.000
Magnesium sulphate	.000
Sodium chloride	20.397
Sodium sulphate	3.450
Silica	.257
Nitrogen pentoxide	.212
Oxides of iron and aluminum	.616
Organic and volatile	23.815
Total	132.480

No. 5.—Water saturated with gypsum, which is successfully treated in a horizontal boiler, through the use of soda ash, and which scales badly during one week without treatment.

Grains per U. S. Gallon	
Sodium chloride	.753
Sulphur trioxide	53.274
Magnesium oxide	4.869
Calcium oxide	34.637
Alkalinity	8.60
Hardness, Clark	58.50°

No. 6.—Representative of water from many lakes in New York State. A spongy scale is produced, which is difficult to remove, but considerable time is required to deposit enough to do damage.

Grains per U. S. Gallon	
Calcium carbonate	4.046
Magnesium carbonate	.466
Calcium sulphate	.538
Magnesium sulphate	.660
Chlorine	.100
N_2O_5	.063

No. 7.—Water producing a flint-like scale in water tube boilers.

Grains per U. S. Gallon	
Calcium sulphate	17.33
Calcium carbonate	8.36
Magnesium carbonate	4.89
Sodium chloride	.74
Organic and volatile	8.18
Total	39.50

No. 8.—Removal of scale forming matter in a line steam heater and softener.

	RIVER	HOT WELL	FILTER
Total Solids	26.410	20.117	18.363
Alkalinity	6.37	3.86	1.17
Calcic oxide	5.395	4.678	3.456
Magnesic oxide	1.128	.701	.000
Sulphur trioxide	2.800	2.105	1.631
Chlorine	4.950	5.731	5.613

THE BOILER WATER

EDWARD BARTOW

Wherever the water supply has to be raised, with the exception of those plants which are driven by electric power or by gas or gasoline engines, we find the boiler water an item of interest. A very few plants obtain their water supply from artesian wells located at a level above the city, or from wells which have sufficient pressure to force the water through the mains. This interest is not very general in the East or far West, as the water for many plants is supplied by gravity flow from upland reservoirs. In the Middle West the boiler water is a matter of vital importance to nearly every water works company.

The quality of water differs so greatly that no general rules can be laid down.* Each water must be considered by itself, together with the accompanying conditions. It may be more practicable to use a poor water than to attempt to make it better.

Boiler water troubles due to some property of the water are corrosion, scaling, and foaming. A water may have more than one of these troubles.

The corrosive waters are either very pure waters or waters containing dissolved gases, acids, or substances like chloride of magnesium, which at the boiler temperature will form acids. The waters from which scale is deposited contain salts of calcium, magnesium, etc. The scale is formed especially when the carbonates or sulphates of the above elements are present. The scale is more or less hard, varying according to the amount of the sulphate. When chlorides or nitrates of calcium and magnesium are present, especially if the carbonates are low, in addition to the scale there will be pitting under the scale.

The waters which foam have an excess of salts of sodium or potassium. The tendency to foam is increased by an excess of organic matter or by matter in suspension.

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*See also Fuller, Water Softening for Municipal Supplies, this Journal, 1906, page 113.

All of these difficulties can be remedied. Corrosion is remedied in the case of very pure waters, by the addition of sufficient salts so that there will be no tendency for the iron of the boiler tubes and plates to dissolve. Corrosion is remedied in the case of the acid waters by the neutralization of the acid or by the removal from the water of the acid formers. Unless large quantities of scaling or foaming constituents are present corrosive waters can usually be treated by adding, with the feed water, caustic soda, soda ash, trisodium phosphate or some boiler compound. If the water contains large amounts of the scaling or foaming constituents outside treatment is to be preferred. Sulphuric acid may be removed by barium hydrate; hydrochloric and nitric acids may be neutralized by soda ash or caustic soda. In order that the acid be not set free at the boiler temperature from the nitrates and chlorides of magnesium, calcium, or iron, soda ash or caustic soda in sufficient amount may be added.

Scaling may be prevented by the removal of the scale-forming material in treatment plants or by the addition with the feed water of substances which precipitate the scale forming material as a sludge, that can be blown out. While the former method is the better, the addition of boiler compounds is in some cases to be recommended. Lime or other substances which are precipitated and form part of the sludge should not be added with the feed water. Sodium salts do not form part of the sludge but increase the tendency to foam. The hydrate, carbonate and trisodium phosphate may be used. The latter is the more expensive but forms a non-scaling precipitate.*

Foaming is not as troublesome to the operator of the stationary boiler as to the locomotive engineer. One hundred grains per gallon is made the limit of concentration in the locomotive.† This means that the amount in the original water must be much lower. Forty to fifty grains per gallon is the limit for waters to be used in locomotives. Much higher concentration can be obtained in the stationary boiler without experiencing any difficulty. Foaming may be prevented by the frequent blowing off of the boiler before the water becomes too concentrated, by the use of condensers to return the condensed water to the boiler so that but little fresh water need be used, or finally, a case which would be rare in the water works plant, by the use of distilled water.

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*Handy, Trans. Am. Soc. C. E., Vol. LIV, Part A, page 1.

†Report of Committee, Am. Ry. Eng. & Maintenance of Way Association Bulletin 83, page 45.

That distilled water can be readily furnished is shown by Ludwig Bothas* who describes a Russian installation, and by W. F. M. Goss,† who estimates that with coal at $1 per ton, distilled water can be obtained for 13c. per 1000 gals.; with coal at $2 per ton the cost will be 20c. per 1000 gals. Whether such an expenditure is warranted will depend upon the conditions. For example, the time that a boiler must be out of commission because of frequent washings, and the amount of extra water that must be heated when the boiler has to be blown off frequently, must be considered.

The troubles caused by the use of any water are evident to the engineer. The cause is not so evident. We may compare this situation with disease. Many people observe the symptoms, for instance, eruptions, fever, headache, etc., yet it needs the skilled physician to properly diagnose the case and suggest a remedy. In this case the symptoms of corrosion, scaling and foaming are evident. The cause is determined by a study of the composition of the water, the composition of the scale, and in some cases the composition of the boiler tubes and plates.

With a view to determining the character and needs of the various municipal water supplies of Illinois, the State Water Survey has been making a study of their composition. The accompanying table shows the character of the waters furnished to about 100 of the cities in the state. It will be noted that there are waters having one or more of the three qualities, (corrosion, scale forming and foaming). Though the table was prepared for a specific locality, conclusions, general in their application, can be made.

By the combination of the acid and basic ions the waters are divided into classes according to the composition. The combinations are made using the basic ions in the order, potassium, sodium, ammonium, magnesium, calcium, iron and aluminium;

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*Massen Distillation von Wasser. Berlin, 1908.

†A Series Distilling Apparatus of High Efficiency, Eng. News, December 1903, page 543.

*Table Showing the Hardness, and the Amount of Lime and Soda Ash Required to Soften the Water Furnished to Ninety-eight Illinois Municipalities **

CITY	CLASS	MINERAL CONTENT Parts per Million							SODA ASH			LIME			CHEMICALS APPROXIMATE COST PER 1000 GALLONS	REMARKS
		Residue	Na_2CO_3	$MgCl_2$	$MgSO_4$	$MgCO_3$	$CaSO_4$	$CaCO_3$	Parts per Million	Grains per Gallon	Lbs. per 1000 Gals.	Parts per Million	Grains per Gallon	Lbs. per 1000 Gals.		
Amboy........	I	389	14.1	....	....	125.2	....	212.6	....	.....	.....	285.	16.6	2.38	$.00714	
Atlanta.......	I	517	46.8	....	....	154.6	....	238.5	....	.....	.....	340.	19.8	2.83	.00849	
Aurora........	II	458	...	....	35.4	35.1	....	165.0	31.	1.8	.26	156.	9.1	1.30	.00650	
Beardstown....	II	373	....	....	65.0	56.4	....	189.2	57.	3.3	.48	211.	12.3	1.76	.01008	
Belleville....	I	370	201.0	....	...	53.3	....	43.4	.....	.....	....	....	.....	.....	....	Deep wells.
	II	393	...	....	21.6	95.2	....	187.2	19.	1.1	.16	241.	14.1	2.01	.00763	Edgmont.
Belvidere.....	II	352	....	....	1.5	116.5	....	193.4	1.3	.1	.01	264.	15.4	2.20	.00670	
Berwyn........	II	735	...	...	182.4	9.7	....	256.8	160.	9.3	1.33	242.	14.1	2.02	.01936	
Bloomington...	II	810	...	....	436.2	130.2	....	156.3	384.	22.4	3.20	463.	27.0	3.86	.04358	
Bushnell.......	II	2038	....	....	228.0	16.4	....	279.8	201.	11.7	1.67	285.	16.6	2.38	.02384	
Byron.........	II	298	....	....	4.0	119.0	....	139.5	3.5	.2	.03	238.	13.9	1.99	.00627	
Cairo..........	II	235	....	....	7.3	21.4	....	47.4	6.4	.4	.05	58.	3.4	.48	.00194	*Clay and silicious matter 103.5
Cambridge.....	I	1052	49.0	....	....	68.6	....	104.9	....	.....	.....	177.	10.3	1.48	.00444	
Canton........	II	1620	....	....	205	....	119.3	157.8	283.0	16.5	2.36	184.	10.7	1.53	.02819	
Carbondale....	I	1818	244.0	....	....	48.0	....	79.0	....	.....	......	237.	13.8	1.98	.00594	Average of 3 analyses from different wells.
Carlyle (a).....	II	248	....	....	20.0	55.4	....	117.3	17.6	1.0	.14	149.	8.7	1.24	.00512	
Carmi (a)......	II	176	....	....	15.8	20.4	....	50.0	13.9	.8	.12	63.	3.7	.53	.00279	
Carrollton ...	II	3121	....	....	289.0	....	162.0	228.4	381.0	22.2	3.17	263.	15.3	2.20	.03830	Artesian well.
	II	348	....	....	4.8	92.1	....	195.0	4.2	.2	.03	234.	13.6	1.95	.00615	Spring.
Chadwick......	I	429	35.4	....	....	148.6	....	212.4	....	.....	.....	335.	19.5	2.80	.00840	
Champaign	I	408	56.0	....	....	101.0	....	202.0	....	.....	.....	276.	16.1	2.30	.00690	
Charleston (a)..	II	270	....	....	21.0	68.0	....	127.0	18.6	1.1	.16	171.	10.0	1.43	.00589	
Chatsworth....	I	702	124.3	....	....	121.5	...	190.0	....	.....	.....	334.	19.5	2.78	.00834	
Chillicothe.....	III	420	....	16.9	94.4	41.1	....	202.9	102.	5.9	.85	222.	12.9	1.85	.01405	

Chrisman....	I	2216	343.5	....	....	30.2	....	38.6	....	.....	.....	....	....	.....	....	Well 140'. Suspended 83.9
	III	571	....	22.1	194.	....	1.5	290.0	197.	11.5	1.64	266.	15.5	2.21	.02303	Well 17.
Clinton......	I	310	18.6	....	......	118.	....	137.	....	.....	.....	243.	14.2	2.03	.00609	Wells.
	I	431	7.2	....	....	144.	....	236.	....	.....	.....	327.	19.1	2.73	.00819	Springs.
Collinsville	II	392	....	....	41.	104.	....	184.	36.	2.1	.30	260.	15.2	2.17	.00951	
Danville (a)....	II	281	....	....	38.	60.	....	135.	33.	1.9	.27	173.	10.1	1.44	.00702	
Decatur (a)....	II	293	....	....	24.8	73.	....	137.	21.9	1.3	.18	185.	10.8	1.54	.00642	
DeKalb........	I	301	60.	....	....	87.	....	132.	....	....	.....	221.	12.9	1.84	.00552	
Dwight........	II	1087	....	....	253.	....	101.	247.	222.	12.9	1.85	256.	14.9	2.14	.02492	
East Dubuque.	I	361	48.3	....	....	109.5	....	113.3	....	.....	....	234.	13.6	1.94	.00582	
East St. Louis..	II	233	....	....	5.5	41.3	....	90.0	4.8	.3	.04	108.	6.3	.90	.00310	
Edwardsville...	II	260	....	....	55.4	23.2	....	131.1	9.	2.9	.41	130.	7.6	1.08	.00734	
Effingham.....	II	257	....	....	38.4	42.9	....	69.2	33.8	2.0	.29	114.	6.6	.94	.00572	
Elgin	II	290	....	....	30.	83.0	....	127.0	26.4	1.5	.21	196.	11.4	1.63	.00699	(a) U. S. G. S.
	I	347	63.0	....	....	98.	....	150.0	....	.....	.....	248.	14.5	2.07	.00621	Deep wells.
Elmhurst.....	II	478	....	....	86.	78.0	....	255.0	76.	4.4	.63	287.	16.7	2.40	.01350	
Farmer City ...	I	719	255.1	....	....	85.0	....	146.4	....	.....	.....	330.	19.2	2.75	.00825	
Freeport.......	II	463	....	....	62.0	109.4	....	221.4	55.	3.2	.46	298.	17.4	2.48	.01204	
Galesburg......	II	951	....	....	135.1	47.9	....	259.3	119.	6.9	.99	272.	15.9	2.27	.01661	Mixture of deep and shallow wells.
Geneseo.......	II	396	....	....	15.6	103.3	....	192.1	14.	.8	.12	252.	14.7	2.10	.00750	
Greenville	II	552	....	....	65.1	96.4	....	277.3	57.	3.3	.48	313.	18.3	2.61	.01263	
Harvey........	II	1204	....	....	239.7	....	225.2	267.5	386.	22.5	3.21	261.	15.2	2.18	.03864	
Havana........	II	196	....	....	15.5	35.9	....	96.1	14.	.8	.12	109.	6.4	.91	.00393	
Henry.........	I	2497	259.1	....	....	60.3	....	94.1	....	.....	....	269.	15.7	2.25	.00675	
Jacksonville....	II	374	....	....	33.2	96.0	....	208.0	29.	1.7	.24	260.	15.2	2.17	.00891	New supply.
Jerseyville....	II	2506	....	....	250.0	....	161.0	157.0	345.	20.1	2.87	204.	11.9	1.70	.03380	
Kankakee (a) .	II	288	....	....	52.0	37.4	....	145.0	46.	2.7	.38	155.	9.0	1.28	.00764	
Kewanee	II	1265	....	....	87.0	....	40.0	175.0	108.	6.3	.90	138.	8.0	1.15	.01245	
Knoxville......	II	1198	....	....	27.9	71.0	....	144.0	25.	1.5	.21	188.	11.0	1.57	.00681	
Lacon.........	III	446	....	6.4	47.0	97.0	....	218.0	49.	2.9	.41	277.	16.2	2.31	.01103	
LaGrange......	II	571	....	....	58.0	111.0	....	288.0	51.	3.0	.43	336.	19.6	2.80	.01270	
LaSalle........	II	432	...	....	80.0	56.0	....	216.0	70.	4.1	.59	233.	13.6	1.94	.01172	

Table Showing the Hardness, and the Amount of Lime and Soda Ash Required to Soften the Water Furnished to Ninety-eight Illinois Municipalities.

CITY	CLASS	MINERAL CONTENT Parts per Million							SODA ASH			LIME			CHEMICALS APPROXIMATE COST PER 1000 GALLONS	REMARKS
		Residue	Na_2CO_3	$MgCl_2$	$MgSO_4$	$MgCO_3$	$CaSO_4$	$CaCO_3$	Parts per Million	Grains per Gallon	Lbs. per 1000 Gals.	Parts per Million	Grains per Gallon	Lbs. per 1000 Gals.		
Lewistown	II	293	...	....	48.8	50.0	....	153.0	43.	2.5	.36	175.	10.2	1.46	.00798	
Marshall	II	228	....	....	20.0	35.5	....	131.0	17.6	1.0	.14	130.	7.6	1.08	.00464	
Mascoutah	III	1060	....	10.2	299.0	....	119.0	453.0	368.0	21.5	3.06	399.	23.3	3.33	.04059	
Mattoon	I	611	16	....	....	185.	....	258.	....	.....	.....	399.	23.3	3.33	.00999	Mattoon Clear Well Water Co.
	II	222	....	....	42.	67.	....	96.	37.	2.2	.30	162.	9.4	1.34	.00702	Kickapoo Drain
	II	298	....	....	66.	50.	....	144.	58.	3.4	.48	178.	10.4	1.48	.00924	Little Wabash Reservoir.
Maywood	II	619	....	....	190.2	39.1	....	233.9	167.	9.7	1.38	272.	15.9	2.28	.02064	
Metropolis	III	233	....	2.7	20.0	17.7	....	163.0	17.6	1.0	.14	137.	8.0	1.14	.00482	
Minonk	I	2226	372.8	....	....	14.6	....	20.4	....	.....	.....	....	.....	.....	....	
Moline (a)	II	177.4	....	....	8.3	38.4	....	80.9	7.3	.4	.05	100.	5.8	.83	.00299	Suspended 108.
Morrison	I	314	6.6	....	....	110.8	....	153.9	....	.....	.....	237.	13.8	1.97	.00591	
Mound City	I	281	3.5	....	....	38.0	....	97.1	....	.....	.....	107.	6.2	.89	.00267	
Mount Morris	III	436	....	74.9	30.2	53.6	....	196.2	110.0	6.4	.91	240.	14.0	2.00	.01510	
Mt. Sterling	I	1542	88.	....	....	70.0	....	142.0	....	.....	.....	219.	12.8	1.83	.00549	Variable.
Newman	I	1221.	76.	....	....	86.0	....	127.	....	.....	.....	226.	13.2	1.88	.00564	
Normal	I	410	153.	....	....	83.	....	131.	....	.....	.....	263.	15.3	2.20	.00660	
Oak Park	II	856	....	....	175.0	....	9.0	211.	154.	9.0	1.28	200.	11.7	1.67	.01781	Average of 2.
Onarga	II	1068	...	....	356.4	....	5.2	458.	314.0	18.3	2.61	418.	24.3	3.48	.03654	
Oregon	II	331	....	....	8.0	125.7	....	161.5	7.0	.4	.06	260.	15.2	2.16	.00708	
Ottawa	I	398	69.7	....	....	95.2	....	159.9	....	.....	.....	253.	14.8	2.12	.00636	
Palatine	II	701	....	....	269.4	....	62.1	118.8	237.0	13.8	1.97	192.	11.2	1.60	.02450	
Paris	II	443	....	....	58.4	102.1	....	188.2	51.4	3.0	.44	268.	15.6	2.23	.01109	
Pekin	III	416	....	41.7	82.1	46.4	....	187.5	119.0	6.9	1.00	229.	13.3	1.90	.01570	
Peoria	II	339	....	....	1.8	85.0	....	160.0	1.6	.1	.01	203.	11.8	1.70	.00520	
Peotone	II	604	....	....	126.0	35.0	....	302.8	111.0	6.5	.92	274.	16.0	2.28	.00604	
Plainfield	III	854	....	66 6	171.0	42.2	......	198.0	225.0	13.1	1.90	286.	16.7	2.38	.02614	

Polo..........	II	367	....	....	8.6	134.4	....	173.2	7.6	.4	.06	279.	16.3	2.33	.00759	
Prophetstown..	II	339	....	....	60.8	35.7	....	195.9	53.6	3.1	.44	186.	10.8	1.54	.00902	
Quincy (a).....	II	203	....	....	12.3	47.0	....	90.0	10.8	.6	.09	119.	6.9	1.00	.00390	
Rantoul.......	I	357	38.0	....	....	112.4	....	167.9	....	.....	.....	263.	15.3	2.20	.00660	
Riverside....	I	807	60.0	....	....	70.0	....	157.0	....	.....	.....	213.	12.4	1.78	.00534	Well No. 1.
	II	689	....	....	229.	56.0	....	295.0	202.	11.8	1.70	346.	20.2	2.88	.02564	Well No. 2.
Rochelle.......	II	337	....	....	1.1	85.2	....	203.7	.9	.1	.01	228.	13.3	1.90	.00580	
Rockford......	I	351	....	....	....	120.0	....	187.0	....	.....	.....	264.	15.4	2.20	.00660	
Rock Island.	I	82	....	....	....	6.5	..	10.7	....	.....	.....	...	....	......	....	March 1902.
	II	191	....	....	11.0	40.0	....	87.0	9.7	.6	.08	107.	6.2	.89	.00347	Feb. 1906.
Roseville.......	II	2591	....	....	443.8	....	480.4	194.6	765.0	44.6	6.38	314.	18.3	2.61	.07163	Use Ba(OH)$_2$.
Rushville......	II	4121	....	....	380.4	....	339.7	189.0	599.0	34.9	5.06	283.	16.5	2.36	.05708	Use Ba OH)$_2$
St. Anne.......	II	943	....	....	301.0	....	105.0	293.0	347.0	20.2	2.90	304.	17.7	2.53	.03659	
Shelbyville	II	408	....	....	98.0	53.0	....	210.0	86.0	5.0	.72	231.	13.6	1.94	.01302	City Supply.
	II	279	....	....	25.0	73.0	..	132.0	22.0	1.3	.18	183.	10.7	1.53	.00639	Auxiliary. (a)
Sheldon... ..	I	796	166.9	....	..	25.8	....	35.5	....	.....	.....	.....	.....	.....	....	
Springfield (a).	II	276	....	....	21.0	69.0	....	130.0	18.5	1.1	.16	171.	10.1	1.44	.00592	
Staunton......	II	554	....	....	153.3	....	185.8	....	360.0	20.9	3.00	...	.....	.....	.03000	Free acid and sulphates.
Sterling........	II	332	....	....	25.5	107.2	....	160.6	22.4	1.3	.19	244.	14.2	2.03	.00799	
Streator (a)....	II	325	....	....	61.0	59.0	....	137.0	54.0	3.1	.45	184.	10.7	1.53	.00909	
Taylorville.....	III	458.3	....	23.7	65.4	35.0	....	243.0	84.0	4.9	.70	227.	13.2	1.90	.01270	
Tolono........	I	656	277.4	....	..	104.9	....	202.0	....	.....	.....	399.	23.3	3.33	.00999	
Urbana........	I	408	56.0	....	....	101.0	....	202.	....	.....	.....	276.	16.1	2.30	.00690	
Warren........	III	379	....	3.3	36.0	85.2	....	207.0	35.3	2.1	.30	248.	14.5	2.07	.00921	
West Chicago..	II	381	....	...	22.0	109.1	....	151.1	19.4	1.1	.16	240.	14.0	2.00	.00760	
Wyoming......	I	781	95.5	....	....	85.3	....	73.6	....	.....	......	204.	11.9	1.70	.00510	
Lake Michigan.	II	140	....	....	7.3	29.4	....	81.4	6.4	.4	.05	89.	5.2	.43	.00179	Average for southern end.

*Proceedings Ill. Soc. Eng. and Surveyors, 1909. (a) Average for year, Aug. 1, 1906, to July 31, 1907, Univ. of Ill. Bul. State Water Survey, Series No. 6, p 17.

and the acids in the order, nitrate, chloride, sulphate, and carbonate. According to this method of calculation the waters of Illinois are divided into three classes:

Class I includes those waters which contain more than enough sodium to unite with all the nitrate, chloride and sulphate ions. These waters therefore are said to contain sodium carbonate and and the carbonates of magnesium, calcium, and iron. The waters of this class will form a sludge or soft scale when used in boilers. With the sodium carbonate in excess there will be trouble from foaming. The carbonates of calcium and magnesium can be almost entirely removed by boiling, or by treatment with the necessary amount of lime. When the sodium carbonate is excessive and there is trouble from foaming which cannot be easily and economically prevented by blowing off, the use of condensers or of distilled water is to be recommended.

Class II includes the waters which have sufficient sodium to unite with all the nitrates and chlorides and with part of the sulphates present. These waters are said to contain sulphate of magnesium and may contain sulphates of calcium, iron and aluminium and carbonates of magnesium, calcium, etc. They will form a scale more or less hard, according to the proportion of the sulphate present. Boiling will remove the carbonates, but will not remove the sulphates of calcium, magnesium, iron or aluminum. These waters should be treated with caustic soda or soda ash to change the sulphate of magnesium, calcium, etc., to sulphate of sodium, and with lime to remove the carbonates of magnesium, calcium, etc. When the amount of the sulphate present is excessive, treatment with sodium salts will increase the tendency to foam. In such cases the use of barium hydrate instead of the sodium salts and lime is to be recommended.

Class III includes those waters in which the sodium is not present in sufficient quantities to unite with all the nitrates and chlorides present. These waters, therefore, are said to contain magnesium chloride. There may also be present calcium chloride, the sulphates of magnesium and calcium, iron and aluminum, and the carbonates of magnesium and calcium, etc. The waters may corrode or pit and will form a hard scale. Boiling will not improve them greatly, as it removes only the carbonates. Soda ash or caustic soda in sufficient quantities to unite with the nitrate, chloride and sulphate present must be used, together with a sufficient amount of lime to remove the carbonate of calcium, magnesium, etc. Barium hydrate may be substituted as in waters of Class II.

All of the waters in the state will yield to the proper treatment, even those containing a large residue.

The factors used in the State Water Survey Laboratory to determine the amount of soda ash, lime, and barium hydrate needed for the proper treatment of the principal substances found in boiler waters are given in the following table:

Magnesium Chloride, $MgCl_2$ to Soda Ash, Na_2CO_3	1.113
Magnesium Sulphate, $MgSO_4$ to Soda Ash, Na_2CO_3	.881
Calcium Sulphate, $CaSO_4$ to Soda Ash, Na_2CO_3	.779
Sodium Carbonate, Na_2CO_3 to Lime, CaO	.529
Magnesium Chloride, $MgCl_2$ to Lime, CaO	.589
Magnesium Sulphate, $MgSO_4$ to Lime, CaO	.466
Magnesium Carbonate, $MgCO_3$ to Lime, CaO	1.330
Calcium Carbonate, $CaCO_3$ to Lime, CaO	.560
Sulphuric Acid, H_2SO_4 to Barium Hydrate $Ba(OH)_2$	1.748
Magnesium Sulphate, $MgSO_4$ to Barium Hydrate $Ba(OH)_2$	1.423
Calcium Sulphate, $CaSO_4$ to Barium Hydrate, $Ba(OH)_2$	1.259

No allowance is made for residual calcium carbonate and magnesium hydrate. The factors must be corrected if the chemicals used are impure.

In the table of Hardness of Illinois Municipal Water Supply the approximate cost of chemicals needed for the treatment of the water is calculated on the basis of lime at $6 per ton and soda ash at $20 per ton. It would seem to the writer that there should be a record at each water plant of the character of the water furnished, and if the water can be improved by treatment, the amount of chemicals necessary for such treatment. This data may not only be of value to the water company, but when it is impracticable to treat the entire water supply the water company may assist its customers by furnishing data to enable them to make use of the water in their boilers most economically.

DISCUSSION

Mr. J. M. Diven, Charleston, S. C.: I had very much hoped that from these three papers by Messrs. Miller, Booth and Bartow, we might find what a good boiler water was. An excessively pure or perfectly pure water will corrode a boiler somewhat. It may be impure, and through its impurities also corrode the boiler or form incrustations. My personal experience is that water is going to do either one thing or the other. The question is where is the happy mean, just how much impurity do we want so as not to produce an excessive incrustation, and yet prevent corrosion?

MODERN BOILER PRACTICE

BY JOHN W. HILL

There are three distinct types of boilers now in general use for steam making, as follows:

1. The plain return tubular boiler, set in brick work, and exposing the under part of the shell to the action of the hot gases, before they ascend at the back end to return to the furnace end through the flues or tubes, and pass up through the uptake and breeching into the chimney.
2. The fire box boiler, which requires no brick setting and is complete when it leaves the boiler shop. This type embraces marine fire box direct and return tubular, and locomotive boilers, and is largely used for marine and portable purposes.
3. Water tube boilers, set in brick work with the hot gases passing around the tubes, of which the Babcock & Wilcox is now the oldest and best known example.

During the past twenty-five years, steam pressures in stationary service have been raised from 100 to 160 lb. per square inch and even to higher pressures; and in a few cases to pressures as high as 280 and 300 lb. per square inch, and our practice in stationary boiler construction, in vogue twenty-five years ago, has been materially revised to meet the new conditions.

There may be boilers in use under modern conditions of service which may not be embraced in the classification above given, but the purpose of the paper is to deal only with the standard and well-known types.

RETURN TUBULAR BOILERS

Return tubular boilers are made and offered in the market as "standard" boilers up to 84 in. diameter and 20 ft. long, to carry 150 lb. pressure per square inch. The shell of this boiler is $\frac{9}{16}$ in. thick, with triple rivetted butt joints. Assuming sheets of a strength of 55,000 lb. per square inch of section, and allowing 74 per cent of the value of the plate for triple rivetting, the factor of safety for such a boiler at 150 lb. pressure will be 3.586, which seems to be too low a measure of safety for steam boilers. This boiler is rated at 225 h.p.

Return tubular boilers set in brick work are rarely used for steam pressures above 130 lb. per square inch.

This type of boiler, however, for the pressures which it will safely carry, is economical in the use of fuel, and has many friends among steam users, but owing to the demands for increased pressures, for high expansion engines, some other type of boiler must be sought. Of course by making the shell plates sufficiently thick, the return tubular boiler may be adapted to high pressures, but only with a sacrifice of economy. The large and comparatively thin shell surface constitutes the chief merit of this type of boilers, and when thickening of the shell to meet high pressures is resorted to, the transfer of heat from the furnace to the water is slower, and the amount of heat absorbed by the water from the shell in a given time, is proportionally reduced. The bulk of the work, as stated, in a return tubular boiler is accomplished by the shell and it is only with thin shells that high fuel economy can be obtained.

FIRE BOX BOILERS

The fire box boiler of the locomotive type with thin water legs is too well known to call for special description. I am not aware that such boilers have ever shown high economy of fuel and they are used now only when no other type is quite as convenient, but for locomotives, contractors' equipment, traction and farm engines, and service requiring portability, this type of boiler will always have its place, and within its range of capacity and economy will always be in favor. Tests made a number of years ago with a Baldwin locomotive indicated that with the water legs clean and the fire box surfaces in good condition, from 75 to 80 per cent of the steam was made in the fire box, and from 20 to 25 per cent of the steam, in the tubes. At the same time, the temperatures of hot gas taken with a pyrometer, in the smoke head showed from 1000 to 1100 deg. Fahr., indicating that at least 50 per cent of the heat of the fuel was lost in the stack.

The marine fire box boiler, with corrugated fire boxes of the Fox-Morrison type, is an ideal boiler for high steam pressure and high economy, and barring cost will meet all conditions now set up for modern boiler practice; such boilers have been fitted with underfeed automatic stokers, but they are better adapted to hand firing, and in test trials and otherwise have made records for economy that cannot be excelled.

These boilers have been built with return tubes, in which case the fire box is continued of full size from the front to the back head, at which point a separate steel combustion chamber lined with fire brick is formed, and the hot gases are conveyed to the tubes through the combustion chamber. At the front end the boiler is provided with an uptake leading to the stack or to a breeching connected to the stack, in this respect resembling the old standard return tubular boiler.

Another form of marine fire box boiler has the combustion chamber at mid-length of the shell, the fire boxes extending from the front head of the boiler to the front sheet of the combustion chamber, and the fire tubes extending from the rear sheet of the combustion chamber to the back head of boiler. In this form of boiler, the hot gases are usually brought forward under the shell and drop into a flue or downtake which leads to the stack.

The marine type of fire box boiler has been so thoroughly tried out in ocean-going vessels that aside from cost and floor space required, it may be regarded as capable of satisfying all conditions for high economy of fuel and high steam pressures.

WATER TUBE BOILERS

The water tube boiler is a comparatively modern invention, although several attempts have been made at different times during the past century to develop a boiler of this kind for steam pressures as high as any carried today. Jacob Perkins and others, eighty years ago, had as accurate a conception of the advantage of high pressure steam as we now have, but he lacked the boiler to make it in economically, and the engine to use it in after it was made, and high steam pressure waited until the modern water tube boiler and triple expansion and turbine engines were designed. It is probable that the boiler led in the advance of steam pressure and engine economy, and that the development of the modern high duty engine followed. At any rate, a plain compound engine with pressures of 100 to 120 lb. per square inch, could give all the economy of steam practically possible at these pressures, and higher economy of steam consumption meant higher steam pressures and the division of the engine work among more steam cylinders.

In discussing boilers and their effect, I am having in mind principally water works practice, although so far as the boiler is concerned, the economic effect would be the same in any other field of steam power development.

Originally the water tube boiler was sold upon its merits as a safety boiler; steam pressures carried were no higher than with shell and locomotive boilers; indeed, locomotive boilers for years have been worked at pressures of 150 to 180 lb. per square inch and plain return flue boilers 48 and 54 in. diameter of shell and 28 and 30 ft. long on western river steamboats have carried 200 lb. pressures since steam boating became an art. The pressures on railroads and steamboats were not designed for economy of steam consumption, but to enable a small engine to pull a large load, and long before the water tube boiler became a marketable commodity, high steam pressure with locomotive fire box and return flue boilers was well known, and when one of these boilers let go from weakness or excessive steam pressure, it made people sit up and take notice, that is, those of the people in the locality who were able to sit up after the explosion.

The danger from explosion in stationary practice has been largely reduced by the water tube boiler, and its merit in this respect has compelled the manufacturers of shell and plate boilers generally to demand better materials and perform better work, to render the other types of boilers equally safe under the allowed working steam pressures.

The water tube boiler has, however, done another thing; it has set a new standard of boiler economy and made each pound of coal do more work, furnish more power and give a better account of itself in the furnace, than it usually did before, mainly by reason of the fact that such boilers with a little care can be practically renewed from time to time and put in condition almost, if not quite equal to new. Excepting the water tube boiler and its setting are kept in good condition, I have found that the economy falls off more rapidly than with shell or fire box boilers, and the neglect which the latter kind of boilers often suffer is not admissible with water tube boilers without exciting notice.

The early Harrison sectional boiler made up of cast iron hollow spheres about five inches diameter and put together on ground joints, was popular at one time upon the sole ground of safety, it being argued that in a case of overpressure or weakness of a unit, that one unit only could break, whereupon the pressure would be lowered, and aside from the possible scalding of men in the fire room, no serious damage could follow the rupture of one of the spheres. I do not recall that much was ever said for this boiler about economy of steam production, and it is not probable that it was an economical boiler for heat transmission for cast iron is not as good a conductor of heat as wrought iron or steel plate, and the thickness of the cast iron shells was even greater than the usual thickness of shells in return tubular shells and fire boxes and tubes in marine boilers, and tubes in water tube boilers.

In water works practice each kind of boiler has its champions and it has been my good fortune to try out each kind with gratifying results. With pressures not in excess of 130 lb. per square inch the plain return tubular boiler carefully set, with grates and furnace adapted to the fuel to be burned and hand fired or with a good automatic stoker will give a satisfactory economy and capacity for heating surface, and will contribute its share toward a high engine duty.

The marine fire box boiler with return tubes, which is found in many pumping stations in the east and represents exactly the kind of boiler almost exclusively used in ocean-going steam vessels, when fired with either hard or soft coal has given economic results not to be surpassed.

From personal experience with marine fire box boilers, I prefer the return tubular type in which the hot gases are taken upward from the front end of the boiler to the chimney. In this type the course of the hot gas is horizontal and upward, although the experience of others has shown that the marine boiler with the combustion chamber in the center instead of at the back end, has given equally as good results. The return tubular marine fire box boiler can be and usually is built of shorter length than the internal combustion chamber type and a larger steam capacity can be assembled in a given space. Moreover it brings all important joints to the ends of the boiler where they are readily accessible for inspection and repair, and with the same temperatures of waste gases in the uptake or downtake, the efficiency of the return tubular type should be the highest.

COMBUSTION IN FURNACES

The combustion chambers in certain kinds of boilers are such only in name. Combustion of solid and gaseous fuel must be effected in front of the furnace bridge wall and not behind it. If the total heat due the fuel is not developed before the hot gases pass over the bridge, it is very doubtful if anything can be done afterwards, which will effect combustion, or convert carbon monoxide into carbon dioxide. Furnaces should be so constructed and draught or air should be so supplied as to secure complete combustion over the grates, and if this is not done a reduced efficiency of fuel is bound to follow. With furnaces altogether of iron or steel, excepting bridge walls as in fire box boilers, the draught or supply of air by blast must be adapted to the maximum rate of coal consumption or poor combustion and low fuel efficiency will be the result. Draught should be good under all conditions, but it is of vital importance in fire box boilers where, excepting the bridge wall, all radiating surfaces are of metal. It is probable that the high efficiency of marine fire box boilers is due quite as much to the rapid absorption of heat by the surrounding surfaces as by good combustion; while the high efficiency of return tubular and water tube boilers set in brick work is largely due to good combustion of the fuel on the grates.

If steps are taken to furnish the amount of air required, plus a small percentage sufficient to guard against a deficiency when green coal is first thrown on the grates (a condition that is overcome by automatic stokers with a uniform feed) good combustion can always be obtained.

The essentials of a good boiler and furnace are ample and well-designed spaces for circulation of the water, so that the heat may be rapidly absorbed from the water side of the plate or tube, and a draught through the openings in the grates sufficient to insure complete combustion of the fuel. With good circulation of water, the burning of plates and tubes should never occur, and with good draught, through the grate bars, the maximum heating power of the fuel can be developed.

Heating surfaces should always be as thin as possible consistent with safety, because the rate of heat transmission is inversely as thickness of metal, and the greater the resistance of a plate or tube to the passage of heat, the slower will be the rate of heat transmission from the furnace and flues to the water, and the lower will be the percentage of heat developed in the steam.

Both furnace and boiler must be properly adapted to their work, or poor efficiency will follow. Thus the furnace must produce the largest proportion of carbon dioxide, without diluting the hot gases too much with air, and the boiler must absorb the heat as rapidly as it is developed from the fuel. Thin heating surfaces and a rapid circulation will accomplish this, and good draught properly controlled will effect complete combustion.

Of course it must be understood that what would be good draught with a consumption of 15 to 20 lb. of coal per square ft. of grate per hour, might not be good draught for a higher rate of combustion; and while the absorption of heat by circulation would be satisfactory at the rate of 3 lb. of water per square ft. of heating surface per hour, it might not be satisfactory at a higher rate of evaporation. Some furnaces and boilers have a wider range of capacity than others and in instances where the demand for steam will pass between wide limits as in traction power stations, this fact should be borne in mind. Capacity in a boiler house is usually varied by cutting out or cutting in one or more boilers, and high range of capacity in a boiler with economy will reduce the standby charges, by permitting a smaller number of boilers to perform the requisite work and by avoiding banked fires.

The cases are not rare where, without serious impairment of economy, the capacity of modern boilers has been increased 100 or more per cent, thus permitting one boiler, upon sudden call for steam, to perform the work of two boilers.

A modern steam engine will take a wide range of power within economical limits and it is desirable to have the same elasticity in boilers where possible.

AUTOMATIC STOKERS

The rapid introduction of automatic stokers during the past twenty-five years and the permanency of their installation is convincing proof of the advantage of the regular firing of fuel. Expert firemen with the hand shovel, I believe, can operate a furnace to better advantage than a machine, but the average fireman is not expert, and the machine can be depended upon to perform the work of feeding fuel to the furnace at the rate to which it is set, without getting tired. Regularity of feed is necessary for high economy, but even with the stoker, judgment must be exercised in clearing the grates from time to time from clinker and ash, and maintaining the proper supply of air. Filling the hoppers is a matter of common labor and requires no skill.

With automatic stokers, one fireman can serve a half-dozen or more boilers with better results than the average fireman can serve one.

The stoker has made possible the use of low-grade nut and slack coal, which, before its advent for bituminous coal at least, was a drug on the market and at times a positive loss to the coal miner. Nut and slack coal now has a steady market value and is in constant demand for steam purposes, a condition which may be credited to the mechanical stoker. One of the strongest claims that can be made for automatic machine feeding of fuel to a boiler furnace is the considerable saving to steam users by the substitution of nut and slack coal for "run-of-mine," or a more expensive grade of coal, and also the saving to the coal miners by making possible the profitable use of material which previous to the introduction of the mechanical stoker was wasted on the culm bank.

Experience in everything, men and machinery, has in due time eliminated the inefficient, weak and untrustworthy, and with machines, at least, only the best and most reliable will survive the attacks of competition, and the selective processes of experience; and after twenty-five years, there is no mechanical stoker in use today that is not possessed of distinct merit. People may differ on the best way to put fuel on the grate, whether from above or below, but the difference on broad lines will not be based on economy of coal consumption, but rather on mechanical details of the stoker.

Forced draught with an underfeed stoker has given excellent results, and it is probable that more attention will be given to this method of construction in the future.

FEED-WATER FILTERS

To obtain good economy in a steam boiler, the heating surfaces must be kept clean, scale should not be allowed to form and mud and oil must be prevented, as far as possible, from entering the boiler. Feed-water filters and apparatus to reduce the amount of lime and magnesia in hard water, therefore perform a useful work, and contribute to economy of coal consumption and prolong the life and usefulness of a boiler.

Top and bottom blow-offs will largely remove mud, oil and some scale-forming materials, but it is true economy to use the boiler as a steam generator and not as a receptacle for scale and other objectionable matter. The cost of apparatus to reduce the scale-forming properties in water before it goes to a feed-water heater is not great, nor is the labor required to operate it such as to interfere with the routine duties of the men in the engine room of a power station. In large works where the volume of feed-water to be treated is such as to require the services of men especially detailed for the purpose, it will be found economical, duty and repairs considered, to soften hard feed-water before it is pumped into the boilers.

TESTS OF BOILERS AND FUELS

Many tests have been run on boilers, furnaces and fuels, and when it is matter of choice, such tests should always be made under the conditions most favorable to the apparatus tested. If the test be of the boiler, then the furnace, mode of firing, and fuel should be those best adapted to the boiler; if the test be of the furnace or of a stoker, it should be made with a suitable boiler, and with fuel best adapted to it; and finally, if the test be of fuel, then it should be made with a furnace and boiler calculated to show its highest efficiency. It is not meant that any of the conditions for a test should be strained or abnormal, but it is certainly unfair to expect good steam results from fuel, with a poor boiler and furnace, and the same is true of the boiler and furnace when the test is made of either of these. All of which leads to the natural conclusion that for high economy, boiler, furnace and fuel, all must be of high quality. Of course high-class fuel is not obtainable everywhere at allowable prices, but there is no obstacle to having good boilers and furnaces anywhere on the globe, and these can be adapted to the fuel which circumstances make available.

BOILER CONSTRUCTION

In the early construction of water tube boilers, cast-iron headers or manifolds were used, and this led to considerable trouble in the cracking and sometimes blowing out of the headers. To remedy this defect, steps were taken to substitute rivetted steel or iron headers for cast iron, as in the "Heine" type of boiler, and latterly the use, in the Babcock & Wilcox type, of forged steel headers. Cast iron is still sometimes used even up to pressures of 160 lb. per square inch, but this seems to me to be bad practice; so far as strength and safety is concerned, there should be only one quality in the materials entering into a steam boiler and that quality should always be the best. The forged steel header, on the principle of the "Mannesman" tube, is the best construction feature of a water tube boiler, and from being as heretofore the weakest part of the boiler, the "header" now is the part least liable to accident in service. Practically all of the water tube boilers are now furnished with forged steel mud drums, as well as headers, and this affords additional safety. The steam drums by reason of their size or diameter must still be fabricated from steel plates and rivetted up, but in view of the fact that the drum surface is not at all or only in a measure a part of the heating surface of the boiler, these can be given such thickness of plates and rivetted up in such manner as to effectually preclude accidents from steam pressure.

If the design of water tube or marine fire box boilers for high steam pressure is such that castings must be used, these should be of cast steel and not of cast iron, as a measure of safety.

While considering the materials of water tube boilers, it may be well to remark the present general use in main lines of steam pipe for steam pressure of 160 lb. per square inch and higher, of cast-steel fittings, tees, elbows, crosses and sometimes the bodies of stop valves. The ends of extra heavy pipe are now usually expanded into forged steel flanges and the danger from screw joints thereby avoided. Extra heavy lap-weld pipe is safe against rupture if the weld is good, and the weakest part of a modern high-pressure steam line is the bolted joint, or, more properly speaking, the gasket in the joint.

Expansion joints, so called, are now not used in steam lines, and the layout of the steam pipe is such as to compensate for changes of length and dimensions due to temperature.

FLUE VENT

Sufficient consideration is not always given to the area of tubes and flues, to provide for the escape of hot gases; sometimes the flue vent is too large, thus permitting the hot gases to reach the uptake at high temperature before the largest possible percentage of evaporative effect has been realized from the fuel, and sometimes the flue vent is too small, and the passage of air through the spaces in the grates is at a rate too low for complete combustion.

UNIT OF HORSE POWER

The unit of horse power in steam boilers is 30 lb. of steam per square ft. of heating surface per hour, with feed-water at 100 Fahr. and steam pressure at 70 lb. per square inch by gauge. This, with an allowance of 3 lb. of water evaporated per square foot of heating surface, corresponds to 10 sq. ft. of heating surface per commercial horse power. Some boiler builders assume a smaller heating surface per unit of power, and this means a larger rate of evaporation per hour per square ft. of heating surface.

The commercial unit of boiler horse power is equivalent to 34.50 lb. of steam per hour per square ft. of heating surface from and at 212 deg. Fahr.

CALORIMETRY OF FUELS

Many tests with calorimeters and combustion furnaces have shown the ultimate heat value and proportion of non-combustible matter in coal, and it is possible as a rule to relate the heat in the steam to the heat in the coal or combustible and show the efficiency of the fuel and steam generating apparatus. With boiler and furnace of an approved type and adapted to the coal it is possible to have a running efficiency of 75 to 80 per cent of the total heat in the fuel, and a larger percentage of the heat in the combustible, leaving 20 to 25 per cent of the heat to account for all losses, including the heat in the chimney gases; under unusually favorable conditions an efficiency of over 80 per cent has been obtained.

It is entirely possible for any steam user to ascertain the probable heat value of the fuel he is burning, and by simple tests to ascertain the weight and quality of steam made from hour to hour, and reduce this to its corresponding heat value, and if the division of the heat found in the steam per hour, by the heat expended in the coal per hour be less than $\frac{7}{10}$, then he can safely assume that there is something wrong with his steam making outfit.

It may not be out of place to call attention to the advantage of close regulation of draught to the rate of coal consumption and steam pressure, and this can best be accomplished by automatic damper regulators regulated by steam and water pressure. This device will not forget to open or close the damper as required by the steam pressure, and the steam pressure and fuel consumption will be adjusted to the requirements of the engine consuming the steam.

VARIATIONS IN HEATING POWER OF COAL

It should be well understood that there is a wide range in the value of coal obtained from different localities, and that there will be a corresponding range in the steam made per pound of coal, but within reasonable limits, there should be an efficiency of boiler and furnace which will equal from 75 to 80 per cent of the weight of combustible, excepting with coals for which the percentage of non-combustible is so large as to preclude it. Generally from 25 to 35 per cent of the heat of combustion is lost by radiation, from the furnace and exposed surfaces of boiler; by moisture in the coal; by the vapor of water in air; by the combustible gases, and finally by the chimney gases, excepting radiation, all the other losses are measured by the product of the weight of waste chimney gases, into the temperature and specific heat, and to obtain an efficiency of furnace and boiler of 80 per cent of the heat of combustion, the temperature of chimney gases must not exceed 425 to 450 deg. Fahr. and this upon the assumption that the radiated heat can be kept within 5 per cent of the total heat, and temperature of combustion in the furnace will range from 2200 to 2400 deg. Fahr.

Excepting steam made in a boiler, all other expenditures of heat are in the nature of losses from a commercial point of view.

The commercial measure of coal is the pound or ton, but the technical measure is the heat unit. Of two pounds of coal from different localities, the heat value may range from 12,000 to 15,000 thermal units, thus showing that while a ton or pound of coal may have the same commercial weight all around the world, the heat value or real weight will depend upon the source from which the coal is obtained. The best known coals are from some of the Virginia and West Virginia mines, from mines in Maryland, and from the Cardiff mines in Wales.

While writing this paper, the following article from the New York *Tribune* came under my observation:

SMOKE PREVENTION

Tests undertaken several years ago by the United States Geological Survey to determine the fuel value of the numerous grades of coal mined in this country were followed after a time by a study of the feasibility of smoke prevention. A report on the second part of the investigation, just issued, confirms many of the conclusions of unofficial experts and emphasizes anew the fact that the generation of smoke from soft coal is in most cases unnecessary.

It can not be too distinctly recognized that smoke is a product of incomplete combustion, and that incomplete combustion may be due to one of several causes. Since the cause can usually be ascertained and removed, it is generally an easy matter to apply an efficient remedy. In a large number of cases the evil results from careless stoking. If a fire is fed at short intervals and with small amounts, the evil may be suppressed and economy promoted at the same time. Combustion is promoted by keeping the fire "clean"—that is, by keeping the grate free from ashes. This precaution, combined with the right method of stoking, will work wonders. A furnace can not with advantage be made to burn more than a certain quantity of coal. According to experts of the Geological Survey, any attempt to go beyond the limit will prove wasteful besides developing smoke. Still, any effort to secure additional heat in this manner is more likely to succeed with washed coal than with unwashed. A resort to a forced draft also results in great smoke production.

Sometimes the fault lies in the design of the furnace. According to the engineers who have studied the question for the national government, the proper remedy is an alteration in form and size, and not the addition of any of the many patented smoke consumers. Perfect combustion is said to depend largely on giving the air and the gases from the fuel an opportunity to mix before they encounter the boiler surfaces. Hence, any improvement which is made when careful stoking will not suppress the smoke should have this object in view. It is feasible also, before furnaces and boilers are installed, so to plan them that the fuel will be completely burned.

Several things are here mentioned which are worthy of consideration:

1. The feeding of fuel to the furnace.
2. The limitation of a furnace in economical coal combustion.
3. The use of washed coal.
4. Planning boilers and furnaces for complete combustion of fuel.

The note about forced draught resulting in great smoke production which from the *Tribune's* point of view would mean incomplete combustion and waste of fuel, I have not found to be true. My experience indicates complete combustion of fuel and little smoke from bituminous or semi-bituminous coals and a high furnace and boiler economy from well-regulated forced draught; indeed, I think much of the evil of smoke production might be avoided or mitigated by forced draught, automatic stokers, and the proper proportioning of the boiler and furnace to their work.

SUPERHEATING FOR DUTY

E. H. FOSTER.

There is today no simpler method of increasing the duty of a pumping engine than by increasing the temperature of the steam which it uses, without increasing its pressure. This is termed "superheating," and has the advantage of practically universal application.

The steam consumption of any type of engine is materially reduced when superheat is provided, and the amount of fuel required for doing a given amount of work being thus reduced, the cost of pumping is decreased. As this is true in all kinds of steam engines, it is also true in all kinds of steam driven pumping engines, ranging from the highest type of vertical triple expansion and crank and fly-wheel engine, equipped with liberal steam jackets, reheater and all the refinements which modern practice demands, down to the simplest form of trade pump, the greatest saving being found in the least refined type. The amount of fuel saved even in the case of the high grade triple amply repays the cost of installation of a superheater and the investment is even more profitable in connection with compound engines or low duty triples.

Pumping engines usually run so steady and continuously that they are enabled to benefit to the fullest extent by superheating in fuel saving, not being subject to frequent starting up of new fires and stand-by losses, as in the case of electrical generating stations, for instance.

There are other advantages in superheating pumping engines than fuel saving. The maintenance of dry steam throughout a plant will be appreciated at its full worth by operating engineers. Ordinary or saturated steam after being generated in the boiler immediately begins to condense and form water, which process continues while resting in the boiler drum and during its passage through steam pipes to the engine. By superheating, however.

steam is supplied with a surplus of heat, with which to meet the demands of radiation, while passing to the engine, the effect being merely to lower its temperature without condensation taking place.

Superheated steam is desirable for pumping engines whether the service be reservoir, direct pressure or stand-by. In cases where the speed is variable or where the engine is running at reduced speed the advantage of superheat would be especially pronounced, and experience has shown that an engine can be put in service more quickly by superheated steam because of the greater facility in warming up.

The disadvantages of superheating are certainly few. Chief among these would be the cost of the installation of superheaters. This will not be great; usually not more than what represents the fuel saving in a couple of years, and would be largely offset by the elimination of other features from the plant, such as steam separators, traps and steam jackets, or any of those devices which are necessitated by moisture in steam.

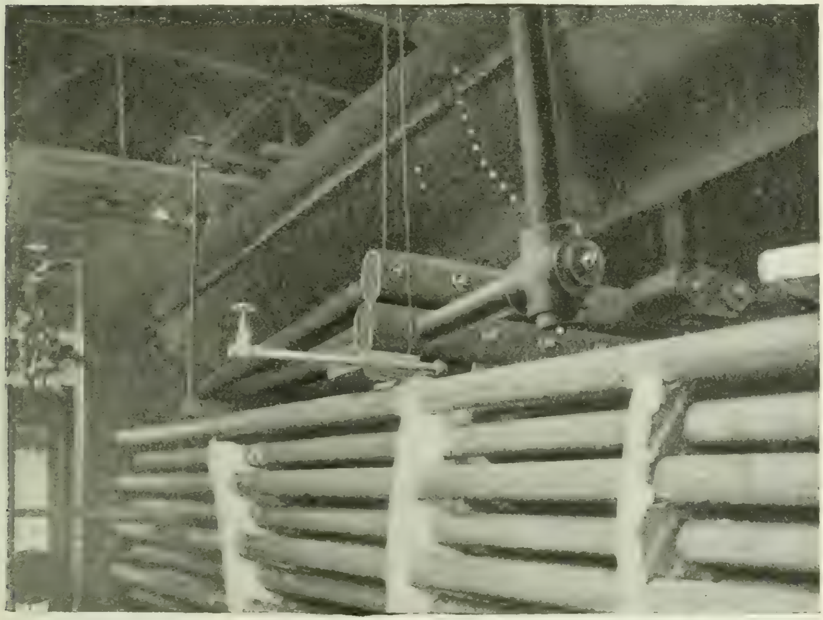
Attention has been called to the fact that if the steam piston or steam valve is made too close a fit in its cylinder, the additional expansion, due to superheat, would cause a cutting or seizing. This is met by the statement that the necessity does not exist for making pistons and valves so close a fit, since the risk of damage caused by expansion due to high-pressure steam of modern practice is too great and also that steam engines which have been in operation for even a short period are bound to have their parts worn sufficiently to be in no danger of cutting as the result of expansion.

It has also been stated that a different kind of oil is required for superheated than for saturated steam. This may be true, but it does not mean that the former requires a more expensive oil. Superheated steam naturally requires an oil with a mineral foundation and which does not volatilize at a low temperature. Frequently where superheaters are installed no change whatever is made in the oil.

It would be merely natural to suppose that a steam engine would be lubricated more easily when using superheated steam because there would not be the water present to keep the oil from the surface. It is interesting to note that no lubricating, whatever, is provided for the cylinders of marine engines when using superheated steam, no more than when these same engines are running with saturated steam.

When a moderate superheat is used, or say a total temperature of 500 deg. Fahr., none other than the ordinary pipes, valves, and fittings suitable for a steam pressure need be considered.

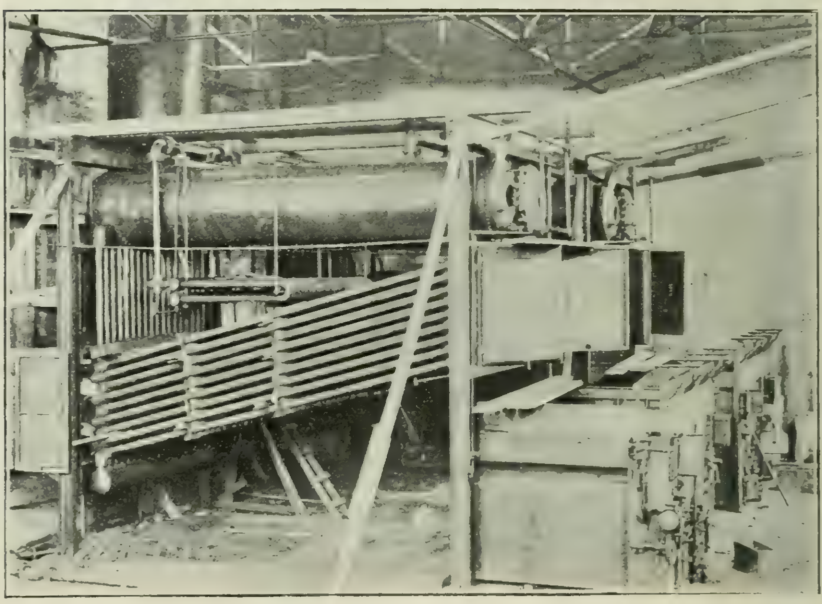
If a very high superheat is contemplated, reaching a total of 700 or 800 deg. Fahr., it would be well to make special provision in designing, not only the steam piping but the engine, and while it is, by no means, claimed that this line of development will not prove advantageous in the future, it is certainly true that up to the present time, at least, more moderate ideas with reference to superheating have prevailed, and this is the field which now stands open to those who are interested in the improvement of pumping engine duties.



FOSTER SUPERHEATER IN EDGEMOOR BOILER AT WILMINGTON WATER WORKS

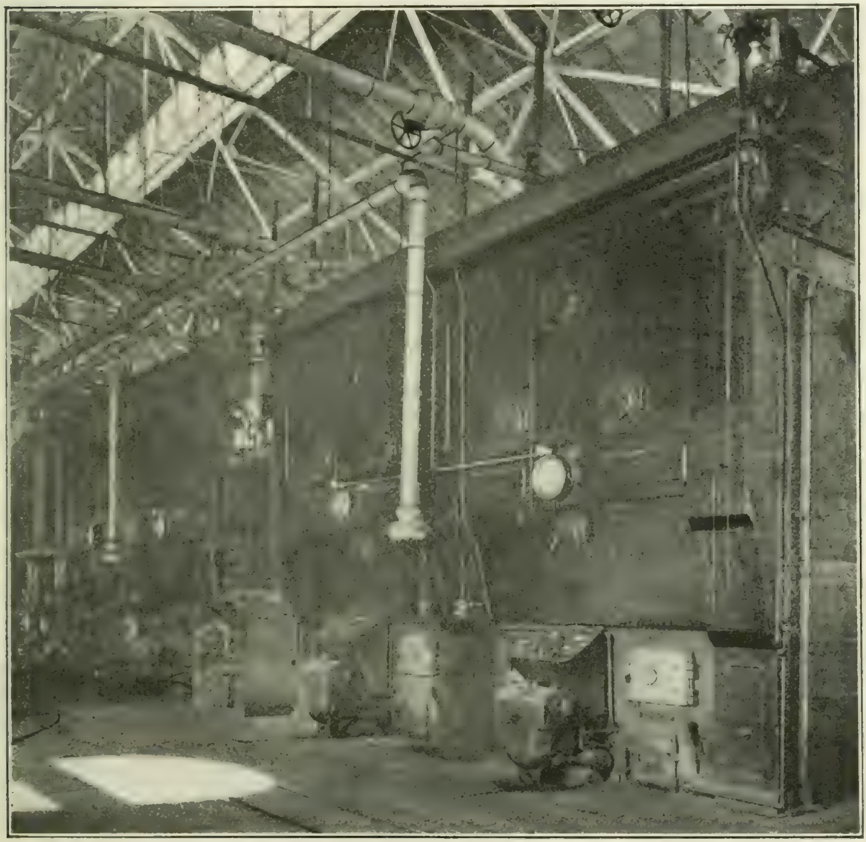
That engineers of water works are awakening to this condition is proved by the fact that since 1901 at least twenty-seven pumping stations in prominent American cities have adopted superheat.

Some embarrassment was felt a few years ago by those who were advocating the use of superheated steam in pumping stations, because of the fact that practically no original data was available, in this country, as to the result which might be expected. It is true that many reports of tests made in Europe have been published and much theory has been set forth in public prints, tending to show great advantages, but an American engineer likes to base his calculations on results which have been obtained nearer home, and under conditions similar to those which he expects to meet.



FOSTER SUPERHEATER IN AULTMAN & TAYLOR BOILER AT TENNESSEE COPPER CO., COPPER HILL, TENN.

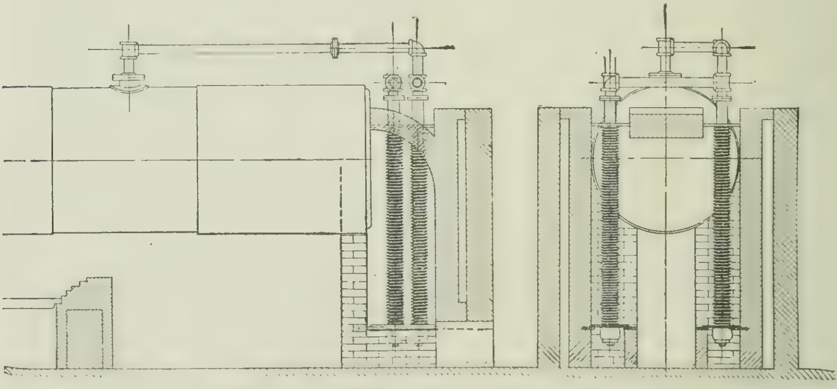
This need is now well provided for, as among the numerous recent installations which have been made in this country there are several instances where careful tests have been made. Probably as the most thorough and exhaustive of these tests may be mentioned those which took place last year at the new low service station of the Cincinnati Water Works. This station is as complete and up-to-date in every particular as can be found anywhere.



FOSTER SEPARATELY FIRED SUPERHEATER AND STIRLING BOILER AT CINCINNATI WATER WORKS

It was designed by Messrs. Benzenberg, Hermany and Bouscaren and was completed by Mr. Benzenberg. The pumping engines were designed by Mr. John H. Lewis. They are 30,000,000 gallons capacity vertical crank and fly-wheel triples with steam jackets, re-heaters, surface condensers and attached auxiliaries. The boilers were of the Stirling type, located a considerable distance from the engines, and the steam mains very large. Separately fired superheaters were installed in the boiler room, which gave ample opportunity for making tests on both saturated and superheated steam, with conditions otherwise identical.

It would be expected that in this type of plant superheated steam would be at the greatest disadvantage in showing a saving in fuel, and the results obtained showed a saving of about 1 per cent fuel for every 17½ deg. of superheat added to the steam in the boiler room and 1 per cent saving in steam for every 6½ deg. of superheat. These results are certainly most convincing as to the advantages of superheating. The wide difference between the saving in fuel and the saving in steam is easily accounted for by the excessive amount of steam pipe radiation necessitated by the arrangement of the plant, also by the very light load on the superheater, due to running only one engine of the four at a time during the test. It is understood that the full details of this interesting test are to be published by the builders of the engines.



FOSTER SUPERHEATER IN HORIZONTAL RETURN TUBULAR BOILER. AT LOWELL WATER WORKS

Superheated steam may be obtained by attaching superheaters to boilers which are already in existence. In such a case the superheater shares with the boiler the heat of the furnace and the superheater and boiler are operated as one, without additional radiation, or floor space, or condensation. Another method which has some obvious advantages is to install a separately fired superheater which may be designed to serve several boilers, If such a superheater is set between batteries of boilers the radiation losses may be reduced to a minimum. No general rule can be established, as local conditions and personal preference are bound to exert the controlling influence in making a decision on this point.

TESTS OF MODERN HIGH DUTY PUMPING ENGINES (CRANK AND FLY-WHEEL TYPE) WITH AND WITHOUT SUPERHEATED STEAM.

BY JOHN PRIMROSE.

The recent official tests of four 30 million gallon pumping engines for the city of Cincinnati, Ohio, supply interesting information concerning the benefit of superheat on engines of this type. The modern high duty pumping engine has reached a stage of development where it is conceded to be the most economical of all reciprocating engines, and considerable doubt existed in the minds of the builders of these engines concerning the benefit of superheating steam for such high-grade machines. The recent tests at Cincinnati prove conclusively that even when these engines are performing at their highest point of efficiency, which they are sure to do on an official test, there is a very satisfactory increase in economy by the use of a moderate superheat. We say that the tests have proved the benefit of superheat conclusively because superheaters of the separately fired type were used, and all of the coal or heat necessary to obtain the superheat was charged against the engines on the superheat tests. Superheaters in the boiler settings would undoubtedly have shown even better results. The plant was operated under practically the same conditions on the saturated and on the superheated tests, the only difference being that on the superheated test the superheater was cut into the line, and all of the steam superheated. During the tests the superheater was operated at only about one-third of its capacity, and it is only fair to assume that the superheater would give better efficiency when operating more nearly at its full capacity. For this reason the results obtained will be better in practice when more than one engine is operated and the superheaters are running at full capacity.

The plant contains the following equipment:

Pumping Engines: Four 3-cylinder, triple expansion, vertical pumping engines, each having a capactiy of 30 million gallons of water in 24 hrs. The engines are of the crank and flywheel type. The diameters of the steam cylinders are as follows: H. P., 29 in., I. P., 54 in., L. P., 82 in., and the diameter of the water plungers, of which there are three, is 37½ in. The stroke of all pistons and plungers is 96 in. All cylinders are steam jacketed on their barrels. Re-heaters are provided between the H. P. and the I. P. cylinders, and between the I. P. and the L. P. cylinders. Each engine is provided with its own surface condenser, the air pump being operated by the main engine.

Boilers: The boilers are of the well-known Stirling type, known as class A, No. 16, and have 2016 sq. ft. of heating surface each. The boilers are equipped with American stokers, having 42 sq. ft. of grate surface.

Superheaters: There are two Foster superheaters of the direct fired type. Each superheater contains 1160 sq. ft. of heating surface, and has 8 sq. ft. of grate area. The superheaters are equipped with shaking grates and are hand-fired.

Economizers: Green economizers are located in the flue common to both the boilers and the superheaters.

Fuel: Pittsburgh nut and slack coal was used in tests.

Lay-out of Plant: The accompanying cut indicates the arrangement of boilers, engines, and superheaters. There is of necessity a considerable length of steam line, which was designed for saturated steam and so is of considerably larger diameter than would be necessary for superheated steam. This has resulted in a radiation loss, causing a loss in superheat between the superheaters and the engines averaging 20 per cent. This can be improved upon by using pipes of smaller diameter.

Some of the figures taken from the records of the official tests are given below.

The very considerable reduction in the steam used in jackets and receivers indicates that the cylinder condensation is less with superheated steam and that less heat is required from the jackets in order to insure the steam, passing through the engine, being dry at the end of expansion in the low-pressure cylinder. It is further interesting to note that the temperature of the exhaust steam leaving the low-pressure cylinder is very consid-

Boilers and Superheaters.

Date	Sep. 1–7, '08.	Sep. 16–22, '08.	Oct. 5–11, '08.	Oct. 27. Nov. 2, '08'
Duration	144 hrs.	144 hrs.	144 hrs.	144 hrs.
Temperature feed leaving economizers	195.6°	211.6°	211.82°	202°
Moisture in steam entering superheater			.90%	1.06%
Temp. steam entering superheater			367.3°	369.0°
Temp. steam leaving superheater			487.6°	494.26°
Superheat at superheater			120.3°	125.26°
Superheat at throttle			98.98°	94.96°
Steam pressure in boilers	153 lbs.	156.4 lbs.	153.3 lbs.	158.4 lbs.
Total dry coal burned under boilers, lbs	136,986 lbs.	139,877 lbs.	119,371 lbs.	118,882 lbs.
Total dry coal per hour	951.3 lbs.	971.0 lbs.	829.0 lbs.	825.6 lbs.
Total water evaporated	1,337,438 lbs.	1,372,862 lbs.	1,202,716 lbs.	1,152,918 lbs.
Dry coal used by superheater			10583 lbs.	10258 lbs.
Total dry coal used	136,986 lbs.	139,877 lbs.	129.954 lbs.	129,140 lbs.
Evaporated from and at 212° per lb. dry coal, including economizer	10.95 lbs.	11.08 lbs.	11.48 lbs.	
Evaporation from and at 212° per lb. dry coal, including superheater			11.30 lbs.	10.89 lbs.
Efficiency of boiler	75.9%	74.6%	76.9%	74.2%
Including economizer	79.9%	80.3%	83.5%	81.3%
Including economizer and superheater			82.2%	
Temperature of steam entering superheater			367.3°	369.0°
Temperature of steam leaving superheater			487.6°	494.26°
Degrees superheat			120.3	125.26
Specific heat used			.568	.569
Coal burned per hour under superheater			75.118 lbs.	72.5 lbs.
Moisture in coal, per cent			2.093	1.7413
Dry coal per hour			73.546 lbs.	71.236 lbs.
B. T. U.'s per lb. dry coal			13.280	13,254
Total B. T. U.'s in dry coal per hour			976,669	944,162
Steam per hour through superheater			8428 lbs.	8092. lbs.
Moisture in steam			.90	1.06
Pounds moisture in steam			75.85	85.77
B. T. U.'s to evaporated moisture in steam			64,772	73,137
B. T. U.'s to superheat total steam			575,909	576,741
Total B. T. U.'s absorbed per hour			640,681	649,878
Efficiency of superheater, per cent			65.6	68.8
Capacity of superheater, lb., per hour			24,000	24,000
Capacity of superheater on test			35%	33.7%
Capacity of total dry coal burned in superheater			8.15%	7.95%
Total capacity of dry coal burned in boilers			91.85%	92.05%

Engines.

Date	Sep. 1–7, '08.	Sep. 16-22, '08.	Oct. 5-11, '08	Oct. 27–Nov. 2.
Duration	144 hrs.	144 hrs.	144 hrs.	144 hrs.
Total revolutions	134,287	133,911	133,320	134,269
Revolutions per minute, average	15.543	15.499	15.	15.540
Piston speed in feet per minute	248.69	247.98	246.9	248.6
Steam pressure	151.4 lbs.	148.8 lbs.	149.7 lbs.	149.9 lbs.
First receiver	27.04 lbs.	27.81 lbs.	26.39 lbs.	24.6 lbs.
Second receiver	1.89 lbs.	2.15 lbs.	3.25 lbs.	2.75 lbs.
Vacuum	13.81 lbs.	13.92 lbs.	13.99 lbs.	14.10 lbs.
Temperature exhaust L. P. cylinder	98.4°	99.81°	91.98°	89.86°
Pressure in I. P. jacket	30.5 lbs.	35.70 lbs.	29.8 lbs.	28.0 lbs.
Pressure in L. P. jacket	2.18 lbs.	1.54 lbs.	3.21 lbs.	2.5 lbs.
Per cent jacket and receiver drains	14.7	14.87	11.23	10.47
Total head pumped against	139.727 ft.	141.820 ft.	143.241 ft.	140.007 ft.
Total steam used by engines, per hour	8712 lbs.	8927 lbs.	8029 lbs.	7712 lbs.
Water drained from separator	87.99 lbs.	89.27 lbs.	0	0
Steam used by auxiliaries	485 lbs.	496. lbs.	398. lbs.	380. lbs.
Total steam supplied by boiler	9284 lbs.	9512 lbs.	8427 lbs.	8092 lbs.
Pump h.p. for test	754.5	763.7	769.	757.2
I H. P. steam cylinders	811	821.2	829.	806.3
Mechanical efficiency	93.1%	93.0%	92.8%	93.9%
Thermal efficiency of engine	19.86%	19.62%	21.02%	21.99%
Thermal efficiency of plant	15.08%	15.01%	16.33%	16.375%
Foot pounds work per hour	1,493,847,760	1,512,119,011	1,522,572,818	1,485,382,271
Duty 1000 lb. dry steam	171,700,000	169,250,000	189,624,000	194,403,500
Duty 100 lb. dry coal	158,755,000	157,684,000	169,769,475	168,139,941
Coal per I. H. P. per hour	1.160	1.168	1.082	1.105
Steam per I. H. P. per hour	10.72	10.85	9.7	9.55
Saving steam			12.6%	
Saving coal			6.8 %	

erably less when using superheated steam. The reason for this undoubtedly is that less heat is absorbed by the steam from the cylinder walls during the exhaust stroke in the low-pressure cylinder. The losses due to cylinder condensation and to heat thrown away in the exhaust are less when superheated steam is used, and the thermal efficiency of the engine is increased. Add to this the benefit derived from the leakage of valves and pistons being reduced when using superheated steam, and the result is a very satisfactory increase in the economy of the engine. The amount of steam used by the auxiliaries, consisting of the feed pumps, stokers, engines, induced draft engines, etc., is comparatively small, but the benefit of using superheat on these auxiliaries is very marked, and this has resulted in the superheat increasing the thermal efficiency of the plant more than the thermal efficiency of the engine considered by itself.

The steam and coal consumption of these engines when using saturated steam is so good that it is remarkable. Even with this remarkable showing, however, there are evidently losses which to a certain extent can be decreased by using superheated steam, and the use of superheated steam in this instance has resulted in a performance which has never been equaled in this country.

DISCUSSION

Mr. John Primrose: Mr. Chairman and Gentlemen, Mr. Foster has written his paper dealing with the question of superheated steam for increasing the duty, in a general sort of way, advocating superheating of steam for the operation of water works pumping engines. My paper follows with a short description of a recent test made at Cincinnati. It brings the thing down to facts. We are very glad at this time to be able to give you this paper, because it is the first instance, so far as I know, of a modern high-duty pumping engine with a separately fired superheater arranged for testing with both saturated and superheated steam. The coal necessary to superheat the steam was carefully measured. It was possible to do so because of the type of superheater used, having its own furnace, so that there was no question about the amount of coal required for that purpose.

The result of the test was, that a saving in fuel of between six and seven per cent was obtained from the entire plant, not only an increase in the economy of the engines themselves, but also of the auxiliaries throughout the plant, and a reduced radiation from the steam line.

That is exactly the thing which is of interest to water works engineers, because it shows just what can be obtained on the entire plant rather than if the test were made on the engine alone. It brings the thing back to the coal bill in dollars and cents.

The problem of superheating in this country has been worked upon for the past six or seven years, and there have been various tests made of different types of engines in power plants throughout the country, all of which have shown a gratifying saving; but until this test, so far as I know, none has been made on a modern high duty crank and fly-wheel pumping engine which, as shown by the paper, has proved an economy in fuel and a state of efficiency higher than any steam engine has heretofore shown. The result of the saturated test showed that the engine was extremely economical of steam even under those conditions.

There has been some doubt expressed of the benefit of superheaters on an engine, where such great pains has been taken to make the engine as economical as possible; and this test I think proves absolutely its utility even on the most economical type of present high-duty pumping engines; and that even on the most economical type of steam engines superheating shows a gratifying saving.

I think it is probable that the next step in the development of steam economy in water works is going to be in the direction of superheating; in the meantime I think, as perhaps all of you do, that it is well worth while to consider superheating in pumping engine plants.

BOILER-ROOM SYMPOSIUM.

BY JAY M. WHITHAM, PHILADELPHIA

INTRODUCTORY

When the Secretary of the American Water Works Association requested me to write upon this topic, I supposed that the task was easy, because I looked at the first two words of the subject and did not comprehend the meaning of "symposium."

When, however, after his repeated urgings, I started to gather a few fag ends for an article and ran up against the word "symposium," I must confess that its meaning was not plain. Accordingly I consulted the Century Dictionary, which is supposed to give the most up-to-date meaning of terms, and learned that "Symposium" means "a drinking together; a compotation; a merry feast; a convivial meeting."

Of course, I can understand why this is a convivial meeting, because it is a symphony of water works men who are noted for never drinking anything that they pump, and who are to meet on this festive occasion in the great beer city of Milwaukee.

Just why you should expect a man from Philadelphia to contribute to this jollification passes my comprehension. This is really a reflection upon the attention which your local Reception Committee is giving the members of the Association.

Thinking, however, that perhaps the Century Dictionary did not give the full meaning of the word "symphony," I consulted Webster, which was the standby when I was a boy, and he says that "symphony means harmony."

Harmony is generally considered allied to music, and perhaps the Secretary expected me to write upon the dulcet tones of the whistle of a high and low water alarm gauge, or the seductive strains of a steam whistle, or calliope. After a disastrous boiler explosion, harmony generally prevails, because there isn't anything to get out of order. Everything has already gotten out of order and quiet reigns supreme. At such times, however, there is a great want of harmony between the water in the faucet, the unlaundered washing, the uncooked dinners, and the money that the taxpayers or stockholders have to expend for making good the damage.

Perhaps Mr. Secretary intended me to write about the "harmony" that ought to exist between the coal pile and the work done; or between the coal pile and the fireman; or between the coal pile and the furnace; or between the furnace and the heating surface of the boiler; or between the boiler and the chimney; or between the boiler and the pumping engines.

Imagining that the Secretary really did intend me to write something upon the boiler-room, regardless of the festive occasion which the members are now enjoying, I would state the following:—

FIREMAN

He ought to know his business; not think that he knows more than he does; ought to be willing and able to learn more and more day by day about coals and their combustion; should be sober, alert, faithful, and a worker. He ought to know that a coking coal requires different treatment from a caking coal; that it does not pay to disturb an anthracite fire; that coal fired frequently in light doses is better than when fired heavily at long intervals.

There is a difference of 10 per cent between the work done in fuel economy between the day when the fireman is strong and well and the day when he is ill, or has stomach disorder, or has been up with the baby all the previous night.

Again, there is 10 per cent difference between heavy firing at long intervals—with a pipe smoke between times and a yarn spun with a comrade—and light frequent firing.

These two conclusions are based upon actual tests in commercial practice, which I have made.

In general, aside from the smoke question, it makes but little difference whether the coal is lightly spread over the grate by the alternate door method of firing or coked in front and then pushed back. In either case the grate should be covered and continuously covered, and the depth of covering should be not less than 6 in. in any part. Some of my best coal economies have been obtained with semi-bituminous and bituminous coals fired 12 in. thick. Of course, if the boiler is overloaded and the fire must be pushed, or if the draft is weak, the fire must not be heavy. The conditions of operation and draft, as well as the kind of coal, must control the depth of the fire on the grate.

The fireman should—regardless of the kind of coal—apply new fuel after the old has come to a white heat and is just passing to cherry-red. This rule is important and means boiler-room savings, and is seldom followed by firemen. The fireman who knows and follows this rule, and is strong and active, is placed at once into the expert fireman class, and is the man engineers and contractors hunt for when a guaranteed duty or performance must be shown.

You may talk about your steam jacketing of pumping engine cylinders, your receiver reheating, your use of superheated steam, and your attenuated vacuum in the condenser, but when a duty test based upon *coal* is to be made, the *fireman* is of more importance than any one of these items singly. If he is important during a dress parade test, he is important in the every-day operation of the plant.

If there must be a difference in pay between the stationary engineer operating the pumping engine and the fireman in the boiler-room—a want of harmony or symphony, as it were, between them in the matter of pay, then in my opinion the fireman should receive the higher pay. This is radical advice—not likely to be followed, but is justified by the want of symphony between the manual labor and skill that must respectively be exerted. The pumping engine generally takes care of itself, the engineer is seldom called upon to adjust it, its valves stay in proper adjustment for several months as a rule, while the fireman can waste by inattention more coal in a day than the engineer can in a week. You will note that the engineer is generally fat and lazy, while the fireman is an athlete.

THE FURNACE

This country is flooded with all kinds of patent furnaces, stokers, smoke preventers, etc. Each is represented by a glib-tongued salesman who presumes that you will swallow his bait and ask no questions.

Mark this! There is no device of this kind upon the market today which contains any fundamental principle of operation different from similar devices thrashed out from 60 to 80 years ago, and when you come down to the best of these devices, this best device will have to hustle to beat a common grate and a skilled fireman, using the same coal.

The furnace ought to be roomy enough to permit the combustion being substantially completed therein. Boilers are generally set too low and the furnace is too cramped.

I have seen the most expert of firemen, firing the best of coals, operate a boiler under its most economic loading, after all conditions had been prepared for the test, and obtain results so miserable that had he secured them in ordinary commercial practice he would have lost his job.

Why the poor result? In this particular case there was a cramped furnace. The volatile in this case, about 22 per cent of the fuel, was distilled and reached the heating or refrigerating surfaces of the boiler at too low a temperature for ignition, and so passed away unignited and unutilized. The richest part of the coal was lost up the chimney.

The gas analysis apparatus does not indicate this waste, since it is hydrocarbon, and all that the apparatus shows is the percentage of corbonic acid, corbonic oxide, and oxygen. And right here let me advise that there is more to be gained by having a fireman who knows his business than by having the boiler-room walls decorated with gas analysis apparatus. The latter is good; a good fireman is the best of all.

There is nothing to be gained by the use of a Dutch oven or dog-house furnace over an ordinary furnace set directly under the boiler if the latter is high enough. I have obtained as high coal economies with one as with the other.

The grate of the furnace must not only hold the coal without waste of fuel in ash, but it ought to contain 40 per cent or more air openings, unless the draft is strong. That is, there should be a "symposium" between the grate and the draft.

In the burning of ordinary semi-bituminous coal, I find the following relation to obtain between rates of combustion and draft:

Pounds of dry coal per hour per sq. ft. of grate	*Inches of draft*
10	0.20
12	0.24
14	0.29
15	0.31
16	0.33
18	0.36
20	0.40
22	0.44
25	0.49
28	0.53
30	0.57

In order to show the importance of proper air opening in a grate, I will state the following conclusion from 49 tests made with a horizontal return tubular boiler, having shaking grates of various patterns.

When burning Georges Creek Cumberland coal with natural draft, the results were:

Air opening in grate	*Economic evaporation at and from 212° F. per lb. of dry coal*
Per cent.	*Pounds.*
50	10.1
65	10.61
70	10.63

When burning Lykens Valley buckwheat anthracite with a steam blast, the results were:

Air opening in grate	*Economic evaporation at and from 212° F. per lb. of dry coal*
Per cent.	*Pounds.*
50	8.1
55	8.92
65	9.09
70	9.33

It is to be remembered that in these 49 boiler tests the same boiler was used throughout and the same fireman, so that the results obtained may strictly be credited to the varying conditions as to grate openings. Shaking grates cost from 100 per cent to 150 per cent more than common grates. They do not last as long. They show no economy over common grates in general. In a plant which operates continuously and where the coal does not clinker, they are of advantage in prolonging the interval between the times for making an old-fashioned cleaning of the fire. Injudiciously used a shaking grate will waste its cost in a very short time in fuel that it throws into the ash-pit.

The extent of grate should be proportioned to the heating surface of the boiler although depending upon the draft, and should be about

One to 30 for small anthracite.

One to 40 for semi- and full bituminous, with drafts from 0.4 to 0.5 in.

One to 60 for semi- and full bituminous with drafts 0.6 or over.

BOILER TESTING

The American Society of Mechanical Engineers has prepared a code of rules for boiler testing which is in general use. This code has been elaborated from time to time until it has become burdensome. If the code were followed strictly, each testing engineer should have a corps of six or seven assistants for a test of a 200 h.p. boiler for 10 or 12 hrs. Few people can afford to pay for such a luxury and it is unreasonable to expect them to do so.

In a boiler test there are but few conditions of paramount importance, or of more than trifling moment. They are:

1. A correct determination of the amount of fuel used and the moisture thereof.
2. A correct determination of the amount of feed-water used.
3. The pressure in the boiler.
4. The temperature of the feed-water.

Of course it is interesting to get a whole mass of data relating to outside and inside temperatures, quality of the waste gases, the drafts in the furnace and at the breeching and in the stack, quality of steam, etc. But all this auxiliary information isn't worth 30 cents.

In making a boiler test, extreme accuracy is important. Every pipe and connection which is not essential to the test should be disconnected or blanked off. It does not do to trust to the tightness of a valve. The water should be weighed or correctly measured in tanks of known volume. It is absurd to trust to the accuracy of a water meter, because no meter can correctly register under the varying rates of flow and pressure obtaining in the feed line between pump and boiler. Of course, the coal should be weighed. The moisture in the coal should be determined—not a week or two after the test is over by drying a handful of it in some chemical laboratory—but at and during the test, by taking a fairly representative sample thereof and drying it at a temperature of from 180° to 210° for a period of from 10 to 12 hrs., the sample being 100 lb. if the scales record only to the half-pound and 25 lb. if the scales record to $\frac{1}{100}$ of a pound.

In making a boiler test, there should be no jockeying and the person guilty of such a practice is not an engineer and is not honest. The point aimed at is truth and the engineer should not care whether he pleases his employer or not so far as ascertaining the facts is concerned. With this in mind it is important that the coal on the grate shall be exactly the same in quantity and quality at the end of the test as at the beginning. It is absurd to start a test with a naked grate and end the test with a burnt-out fire, because this is not commercial, and commercial conditions must control if the results are to be of any value. There is no point in a boiler test requiring such keen observation and judgment upon the part of the testing engineer as the determination of the amount of coal on the grate at the beginning and end of the test.

Knowing that judgment is not infallible and that engineers will err, the American Society of Mechanical Engineers in its Code has wisely prescribed that tests shall be prolonged throughout a period sufficient to minimize any error in starting and stopping. This result is accomplished if the test is conducted throughout a period of 10 hrs. in boilers operated at their ratings. To prolong a boiler test beyond that period is not conducive to accuracy and is burdensome.

Right in this connection I want to protest against a good many specifications written by draughtsmen and others in the employ of municipalities and of the government relative to boiler testing. These inexperienced office men seem to think that a boiler test should be prolonged throughout a period of from 18 to 24 hrs. If they knew more about boiler testing they would see the absurdity of such requirements. In all my boiler trials (over 1000) it has been my practice to hourly determine, as closely as possible, the performance of the boiler. It rarely happens after a test has advanced 5 or 6 hrs. that I am unable to predict to within 2 or 3 per cent of the final result. I have made tests extending over a period of 132 hrs. continuously, but found that at the end of the first 6 hrs. the results were the same as they were for the week's run.

Another element which should be considered in boiler testing is the register of the water in the boiler at the beginning and end of the test. The water column has a dead circulation. It is not exposed to the heat of the boiler and is at some temperature between that of the boiler and the fire-room. Water contracts rapidly when cooling. If the test is started with hot water in the glass and ended with cold water in the glass, there is in many boilers an error of 3 in. in the water level.

TWO IMPORTANT ITEMS

In order to secure greater "symposium" in a boiler-room, it is necessary that (1) no man should be sent into a boiler for repairs or cleaning unless his life is protected by two steam stop valves, both of which should be shut and kept shut; (2) that if the Company or Municipality owning the water works desires to avoid heating water for the sewer, each boiler should have two blow-off valves in tandem.

DISCUSSION

Mr. William Bishop: I would like to ask the Secretary whether there is not in this paper a statement to the effect that a simple plain grate is practically as good as a shaking grate?

Mr. John M. Diven: With a good fireman, yes. In other words the whole gist of the paper is, that more depends upon the fireman than on the mechanical equipment.

Mr. William Bishop: I would like to know from our members whether they find that the plain grate is a practical grate, though perhaps it is not strictly in the line of the present discussion.

Mr. John M. Diven: I think we have all noted the difference in firemen. I know I have myself, between two shifts, between the night and day firemen. I have noted instances where the night fireman, although the night load was very much less, would actually use more coal, without any regard to the decreased amount of water pumped, than the day fireman did. I have noticed similar differences between two firemen on the same shift and when the amount of water pumped was practically the same; one might use a thousand pounds more coal than the other. I think what Mr. Whitham said about the efficiency of the fireman contains a great deal of truth.

Mr. William Bishop: I think we are all satisfied of that fact. The question with me was, whether, if you take the same fireman, there is any advantage in having a good shaking grate?

President French: In answer to that, I think it depends a little upon the size of the furnace. Taking a one hundred horsepower furnace, five by six feet or something similar, or taking a boiler of two hundred and fifty or possibly three hundred or three hundred and fifty horse power, if you have a pretty big grate to handle I think it is the general opinion that a shaking bar with a big grate surface is a rather desirable feature, not only on account of the cleaning of the fires, but the great saving of time. I have seen some furnaces of five hundred horsepower with a stationary bar where the engineer complained strenuously because the management were not willing to put in shaking bars. The furnace was, I think, thirteen by seven feet, over ninety square feet and with three fire doors. To clean such a furnace by hand was a pretty warm job. It would take more than one man to do it quickly enough so that the steam pressure would not go down. The engineer took the position that if he had a shaking grate he could accomplish the work in very much less time and hold the steam better.

I think that is the guarantee made by several of the shaking bar people who manufacture shaking grates.

Mr. John M. Diven: For the information of some of you who have not read the paper, I will read what he says in regard to the furnace, viz: "This country is flooded with all kinds of patent furnaces, stokers, smoke preventers, etc. Each is represented by a glib-tongued salesman who presumes that you will swallow his bait and ask no questions. Mark this! There is no device of this kind upon the market today which contains any fundamental principle of operation different from similar devices thrashed out from sixty to eighty years ago, and when you come down to the best of these devices, this best device will have to hustle to beat a common grate and a skilled fireman, using the same coal."

Mr. S. J. Rosamond: We have four or five grades of coal in the territory that I am now in. I have burned Kansas, Illinois, Missouri, Arkansas and Oklahoma coals. It has been my experience that we must get a grate bar suitable to the coal we are burning. We have one coal that is known as the "Sand Boy" that could not be marketed at all until a special grate bar was found that was suitable for the coal and then the president of the railroad that built the coal road to develop the mines, found it necessary to get expert firemen to demonstrate how the coal should be fired, and how the furnace should be built and equipped with the grates. I think that you should first study the quality of the coal you have and then get a grate adapted to that coal. As the gentleman said, a great deal depends upon the fireman.

Mr. John M. Diven: It seems to me that Mr. Whitham lays almost too much stress upon the importance of the fireman. I do not know whether I want this paper to get out in my pumping plant for I might have to raise some wages. If we hold the engineer responsible, may be that will make him wake up and pay more attention to what the firemen are doing. We must have a responsible head; and, I think, we are more apt to find a suitable one in the grade of engineer than of fireman.

Mr. S. J. Rosamond: I think the responsibility falls upon the engineer after all. I have never had an engineer about me that did not have complete control of his plant. If he could not get a fireman to do the firing to suit him, he got another immediately. The responsibility rests with the man who is responsible for the plant, not the fireman who has got to be made to do his duty.

BOILER EQUIPMENT, PRACTICE AND RESULTS AT PUMPING STATION, WATER DEPARTMENT, HARRISBURG, PA.

BY GEORGE G. KENNEDY.

The boiler equipment at the pumping station of the Water Department of the city of Harrisburg, Pa., is composed of four horizontal return tubular boilers, identically alike and of about 125 h.p. Two were installed in 1901 and two in 1903.

So satisfactory have these boilers been that the same specifications were used for building the two boilers at the filter plant in 1904.

The pumping station boilers furnish steam for a 12,000,000 vertical triple expansion engine or for two 6,000,000 gallon horizontal engines. The two 6,000,000 engines, however, are the reserve capacity and are only used sufficiently to keep them in good condition. In addition to that used for pumping, the heating of several detached buildings is taken care of and steam is also furnished for the jets in the stokers.

The boilers are 18 ft. long and 72 in. diameter. Each contain 64 best lap-welded charcoal iron tubes four inches in diameter. The shell plates are $\frac{9}{16}$ inch thick, of good open hearth fire box steel having a tensile strength of not less than 58,000 or more than 63,000 lb. Heads are of the same quality as the shells and are $\frac{11}{16}$ inch thick. The circular seams are single riveted with one inch rivets and the longitudinal seams are butt jointed, triple riveted with covering strips both sides $\frac{7}{16}$ inch thick.

Each boiler is provided with two 3-inch nickle seat pop safety valves, one 8-inch steam gage, three $\frac{3}{4}$-inch gage cocks and one $\frac{3}{4}$-inch gage glass 12 inches long; also with a 2-inch check and a 2-inch feed valve. The blow-off pipe is controlled by a $2\frac{1}{2}$-inch angle valve and a $2\frac{1}{2}$-inch cock.

The boilers are set in brick double return settings and are supported by lugs resting on plates built into the brick work, iron rollers one inch in diameter being placed between the rear lugs and wall plates. Each is fitted with a class A. G. (17 bar) Wilkinson automatic stoker, operated by a water motor and equipped with steam draft that is connected with a Locke automatic damper regulator governed by the pressure in the boilers.

The chimney is of brick, octagonal in form, and has an inside diameter of 5 ft. and is 100 ft. high.

The feed water can be supplied either through a duplex boiler feed pump connected with a Webster feed water heater, by injectors or, as in the usual practice, by the feed water pump operated by the 12,000,000 gal. pumping engine, which is used almost constantly. The water supplied to this pump goes through a close heater located in the exhaust pipe of the engine between the low-pressure cylinder and the surface condenser. The passage of the water through this heater increases the temperature about 80°.

The stokers are of the regular pattern made by the Wilkinson Manufacturing Company, Bridgeport, Montgomery County, Pa. The coal is fed into the hoppers by hand, as it is thought the plant is too small to make automatic coal and ash handling apparatus economical. It is mechanically forced from the hoppers down an easy incline under an arch until by the time it reaches the ash slide it has completely burned out.

The incline is composed of hollow grates moving forward and backward alternately for a space of about three-fourths of an inch. In the end of each grate bar is introduced a small steam jet that forces steam and air through the openings that are in the steps of the bars and through the fire.

The stokers are driven by an eight-inch hydraulic motor directly connected to the grates and moving at a very slow speed. Power for the motor is furnished through a ½-inch pipe, the water being taken either from the distributing system or through a pump supplied from a tank. When the latter is used the same water furnishes the power over and over.

The steam supply to the jet is connected to the Locke damper regulator and is used intermittently, as the steam rises and falls, opening and closing the damper. The quantity of steam used is estimated at seven per cent and varies with the quality of the coal. The use of the steam is primarily to keep the grate bars cool. There has been but two sets of new bars purchased for the four boilers since they have been in use, although occasionally new tops are placed on damaged bars. This however is not expensive, costing about $3 each.

The boiler house is a well-built and well-lighted structure facing one of the finest residential streets in the city. The outside appearances of the station must always be pleasing and the surroundings kept clean and attractive to prevent criticism. The same care and attention is given to the inside also. The walls and ceilings are painted and whitewashed at frequent intervals and the walls and fronts of the boilers are kept clean and the brass work polished. In fact the same attention as to cleanliness, economy and looking after details is given the boiler room as is usually devoted to the engine room only.

A bath room is connected to the boiler room, in which are the necessary toilet appliances, and each man has a large, well-ventilated locker. Several suits of overclothes of a uniform pattern are furnished every man and they are laundried at the expense of the department.

Three boilers are in service at all times, one being held in reserve after being in use a regular length of time. They are insured and regular inspections are made by representatives of the insurance company.

All coal is weighed before being placed in the hoppers and the meter is read at the beginning of each trick. The coal is conveyed from the bin into which it has been delivered by carts at the street level on a truck holding about 1500 lb. and is run over a track to the boilers. One load is sufficient to fill the hoppers and the charge ordinarily lasts about ninety minutes. The truck is returned to the bin, filled and left there until it is necessary to again fill the hoppers. No coal is stored in the boiler room at any time. The use of stokers does away with the hard work of cleaning fires that is necessary with hand firing. The ashes from the stokers are dropped into the pit every four hours by simply pulling a slide. They are allowed to cool, wet down and then removed.

The fuel used is anthracite coal about the size of rice or No. 2 buckwheat. It is dredged from the eddies in the Susquehanna River right at our door. In the early days of coal mining, the operators prepared no coal smaller than that size called nut and the refuse known as culm was deposited on any waste land available. Many of these large deposits are directly along the banks of the creeks and brooks tributary to the Susquehanna. At the time of every freshet vast quantities of this culm was washed into the water, the largest particles settling to the bottom and being gradually forced down stream. At many places between Harrisburg and the mines vast beds of coal can be seen at low stages of the river.

This coal is pumped with dredging pumps, washed over a screen to get rid of the sand and gravel and hauled to the shore in flat boats holding about ten tons. An outfit consisting of a boiler and pump on one boat, a stern wheel steam boat and about ten flat boats can take out, early in the season when the coal is plentiful, about 60 tons a day. It is delivered to steam users at from $1 to $1.25 per long ton, according to quality. Possibly 30,000 or 35,000 tons are reclaimed at this point in the course of a summer. Towards fall the supply is usually exhausted, but it has always been replenished by the freshets of the succeeding spring. In the last several years the mine operators have been washing these culm banks and securing the small coal for shipment so that possibly the supply of this fuel is short-lived, but it has been used extensively for fifteen years and is still plentiful.

The average result of a number of analyses of this coal shows that it contains 6.12 per cent volatile matters, 79.77 per cent fixed carbons, 13.60 per cent ash and 13,000 B. t. u. Some of the coal is very fine and is lost, the ashes showing 17.79 per cent fixed carbon, 82.21 per cent non-combustible and 2600 B. t. u.

In using this fuel in hand fired boilers it must be mixed with bituminous coal. The stokers in use in the Department are exceedingly well adapted to this material and to soft coal slack and are, in addition, labor savers. The average evaporation is about 7½ lb. of water per pound of coal with feed water at 140° F.

The use of stokers, with the consequent saving in labor and the conveniences provided by the Board for the men make it possible to secure firemen of a higher order of intelligence than is usually found in a boiler room, which undoubtely results in economical operation sufficient to repay for the outlay. Three firemen, each working an eight-hour shift, are sufficient for all purposes and a utility man divides his time between taking care of the boilers, when they are taken off, and the engine room.

The regularity with which the steam pressure is maintained by this equipment and by careful firing is worthy of notice. At times when the speed of the engine is not changed for some reason or other for several days the total number of revolutions on each day is remarkably constant and on several occasions the difference was not over one or two.

During the three months ending April 1, 1909, there were pumped at this station 870,933,300 gallons of water from the clear well to the distributing reservoir, the elevation representing a head of 235 ft. The amount of coal used, exclusive of banking, was 1086 tons and cost $1357.50, or a cost per million gallons pumped for coal alone of $1.56, and for raising one million gallons one foot high of .0066 cent.

During this period the total expense at this station for coal, oil, waste and labor was $3188.24, or a cost per million gallons pumped of $3.66, and a cost per million gallons raised one foot high of .015 cent.

DISCUSSION

Mr. George G. Kennedy: This paper has been printed in the advance copies and was written at the request of the secretary who stated that nothing had been presented that in any way related to a stoker equipment.

The paper explains the appliances installed to burn in the most economical manner the cheap fuel that is local to Harrisburg and which is secured from the same source that also furnishes our water supply—the Susquehanna river. This fuel, which is the washings from the coal mines located anywhere from fifty to one hundred and fifty miles north of our city, costs us $1.25 per ton and from its use we get results that we consider remarkably low when compared with those obtained by the average pumping stations.

Talking about firemen, our firemen have practically an easy job of it. The stokers are self feeding and need but little attention, in fact when adjusted satisfactorily to the fuel they will give the best results if let alone.

Mr. William Bishop: More definitely stating our circumstances, perhaps I can get a little more definite information. Some years ago we were burning hard coal, of pea size, and using a triangular grate bar. We found we could substitute bituminous coal, thereby saving about $500 a year. Lately we have put in a draft system whereby we are able to use a cheaper grade of hard coal, No. 2 buckwheat. It goes a little too freely through our grate, but it has cut down the price of pumping 1,000,000 gallons of water from $4.97 to about $4.50. We find that we can buy barley coal, saving about ninety-five cents per ton more. Burning all hard coal this size by this system causes it to clinker, and we have wondered whether by the use of the shaking grate we would not be able to avoid these clinkers and save having to open the doors to take out the clinkers in the front, with consequent loss of heat.

Mr. A. A. Reimer: Our experience at East Orange may be of some little service. We started using No. 1 buckwheat high-grade anthracite steam coal, which gave very good service; then the demand came for a little higher power, and we put in a forced draft system including a set of grate bars for burning No. 3 buckwheat or barley. We found we got excellent service from the small coal at a very low price, and little of it goes on to the ash pile. I think you will find that the forced draft companies can give you something that will enable you to use the fine coal.

Mr. William Bishop; We use the balanced draft system.

Mr. A. A. Reimer: You may be able to get a grate with small perforations that will answer your purposes. We find the fine coal is quite high in thermal capacity.

President French: There has been very recently in New York some quite exhaustive tests made to determine what can best be used in the way of cheap coals, and how they should be used to obtain the most economical results. It was decided that the very best results obtainable were in connection with burning No. 2 buckwheat with twenty per cent of soft coal mixture, with forced draft. They experimented on all kinds of coals and all kinds of adulterations of the fine coals, from ten per cent of a good grade of bituminous up as high as sixty per cent. Their final conclusions were that straight No. 2 buckwheat—barley as we call it —and twenty per cent bituminous.

would give the best results. The experiments covered a period of several weeks. The chief engineer there, in connection with several other able engineers, is operating the plant now on that basis, and getting excellent results.

MR. GEORGE G. KENNEDY: We have the advantage of getting a better class of labor in our boiler rooms. Everything is kept clean, bath and toilet are handy, and after a man has stood his trick the facilities at his disposal allows him to leave his work in the same presentable condition as is possible with lighter and cleaner employment. With stokers I would rather break in a man who had never had any experience in a boiler room than start one who had worked on a hand fired boiler. The green man is easier instructed in his duties and is not handicapped with ideas that were acquired in his hand firing experience. The only necessary thing usually required is to keep the hoppers filled, and drop the ashes at regular intervals, the stoker does the rest.

A MEMBER: What percentage of steam do you use in operating the stoker?

MR. GEO. G. KENNEDY: I say in my paper seven to ten per cent. Those stokers are blown with steam. On a test I made at one time they ran ten per cent; another time from seven to ten per cent was used in blowing the stokers. With the coal we have it would be economical if it took twenty-five per cent.

MR. JOHN M. DIVEN: What effect does that coal have upon the boiler tubes?

MR. GEO. G. KENNEDY: As clean as with freshly mined anthracite coal.

MR. S. BENT RUSSELL: It is thought that this discussion on the boiler plant or boiler room would not be complete unless it included something about coal handling. I have prepared a brief article on that subject which I now offer as a part of the discussion.

PRACTICAL CONSIDERATIONS IN COAL HANDLING FOR PUMPING PLANTS

S. BENT RUSSELL.

At the Baden High Service Pumping Station in St. Louis, for the year ending April, 1908, there were consumed 1.6 tons of coal per million gallons of water pumped. This plant pumped about 34,000,000 gallons per day average. The lift is about three hundred feet. The average water works pumping plant takes more coal per million gallons.

In any plant some of the coal used must be stored and recovered, the proportion depending upon the convenience of shipping arrangements. Under favorable conditions where coal comes by rail, perhaps one-half the coal would be used as delivered, and one-half would be stored and recovered. The number of handlings would depend somewhat upon the system used.

For the sake of discussion we will assume a plant using two tons of coal per million gallons, and that on the average the coal is handled three times. We have then the equivalent of six tons of coal handled for each million gallons of water pumped.

This gives us some conception of the work of coal handling in a water works pumping station, and its importance relative to the volume of water pumped.

As there are many ways of handling and storing coal involving more or less machinery and plant, it is a matter of some importance that a boiler plant be provided with that system of coal handling that will give the greatest economy. The choice of a system is a local problem, as it depends upon the amount of coal to be handled and other local conditions.

Now it often happens that the choice of a system is made by men having little knowledge and experience in the field, and they are guided by the advice of parties who have machinery to sell or who install plants for profit, and these parties have little practical experience in operating boiler plants. The wise manager knows that it is not always the plant that has the most elaborate labor-saving machinery that brings the best returns on the investment.

In planning a coal-handling system for a boiler plant we must have full information as to all local conditions. Some of these are, the character of the coal, whether it will come by rail, by water or by wagon, the size and regularity of shipments or delivery, the available space for handling and storing, the kind of furnaces, the method of stoking, labor conditions, etc.

That manual labor has a certain flexibility rarely obtained by machinery is well known to the experienced. The reliability of manual labor depends upon labor conditions. To obtain equal reliability with machinery may require a costly duplication of parts. When lump coal is used, manual labor is at some advantage. The loss in storage for bituminous coals is less with lump coal than with crushed. On the other hand, more costly machinery is required for handling lump coal, especially for small plants.

Regularity of operations is greatly to be desired, so it is usually preferable to avoid changes in the character of the coal. On the other hand, we have a better command of the coal market if we are not limited in the selection of coal. To the same end it is better if our plant is designed to be independent as to the coal carriers.

The volume of storage is an important matter, as the cost of systematic handling increases rapidly with the area to be covered. On the other hand the losses from insufficient storage must be reckoned with. Whether it will pay to protect the coal from the weather must be determined. The best way to guard the coal from theft is also a consideration.

In a public pumping plant æsthetic considerations are a matter of some importance and should be kept in mind. Dust, smoke, noise and untidiness are to be avoided.

With such points in mind the designer may proceed in determining what course to follow.

The amount to be invested in plant should not exceed certain limits. To illustrate this the writer will present a computation made for an industrial plant in Illinois, to determine whether to use coal pockets and a lift or to use hand shoveling.

The coal pockets were to be of steel and timber, were to hold four days' supply and were estimated at a cost of $15 per ton

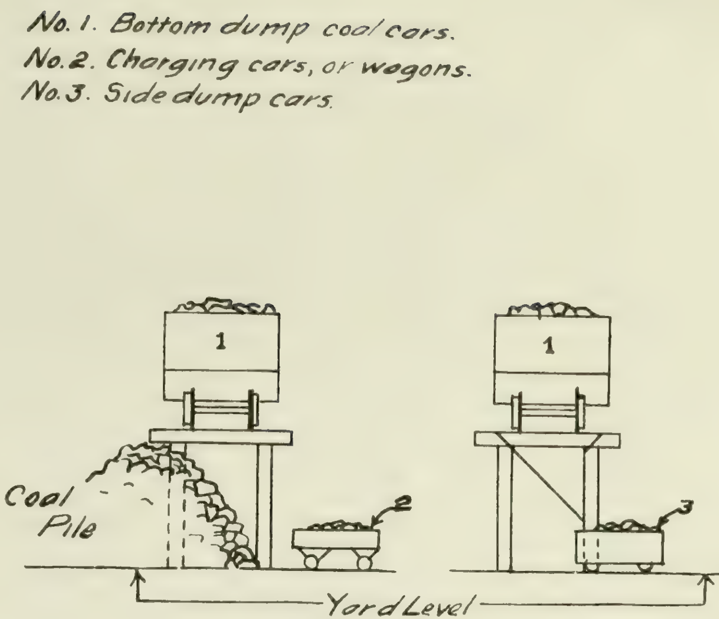

No. 1. Bottom dump coal cars.
No. 2. Charging cars, or wagons.
No. 3. Side dump cars.
1
1
Coal Pile
2
3
Yard Level

Fig. 1.

FOR SHOVELING COAL BY HAND

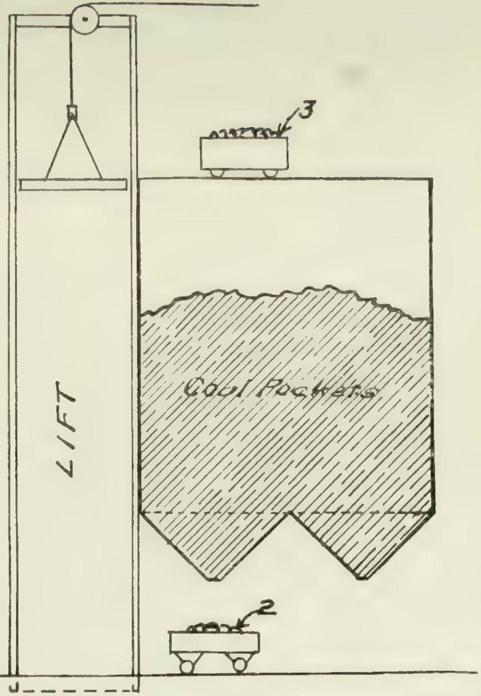


Fig. 2

FOR ELEVATOR WITH COAL POCKETS

capacity. The estimated cost of lift complete was $4000. It was assumed that shovelling by hand would cost ten cents per ton, and operating the lift would cost three cents per ton handled, making a saving of seven cents per ton. See Fig. 1 and 2 of sketch. Charges on lift and pockets were figured as follows:

	Per Cent.
Interest	5
Depreciation	5
Repairs	2
Taxes	1.5
Insurance	0.5
Total	14

A capital of $182.50 at fourteen per cent will yield seven cents per day. For each ton handled we will require four tons capacity of pockets, or $60 worth. Deducting this from $182.50 we have $122.50 as all that may be invested in lift for each ton handled. 32.6 tons at $122.50 gives $4000, or the cost of the lift; hence we cannot afford a lift for less than 32.6 tons per day. The plant under consideration was using lump coal. The value of such a computation depends of course upon the correctness of the information upon which it is based. Moreover, such considerations as reliability of operation, etc., must not be overlooked.

In comparing different systems of coal handling as to relative economy, it is helpful to have knowledge as to the cost of storing coal. The speaker has taken as a basis the estimated construction cost of cars, sheds, pockets, etc., and figured the charges for interest, repairs, depreciation, etc. An allowance for rental of land was included. The results show the approximate costs for storing coal to be in the neighborhood of $\frac{3}{4}$ of a cent per ton per day in cars or in pockets, and of one cent per ton per week in brick or wooden sheds. These figures should of course be used for rough preliminary estimates only, and should be checked by careful computations based on accurate data for a given plant.

The cost of operating coal handling machinery is something that must be worked out in detail for each particular case. It may be noted that the consumption of fuel for driving a well designed coal handling plant is a negligible item. Attendance is the principal source of expense, and the item of repairs is next in importance.

In these days of machinery there is some danger that we overlook one valuable source of power, the horse or mule. In many cases animal power will give the desired results with the lowest cost.

It is worth some extra expenditure to know the duty one is getting from each lot of coal bought. As a pumping plant is usually run it is by no means easy to tell what each lot of coal is doing, i. e., to tell accurately and promptly. The following rules for operating will assist in bringing out some of the difficulties.

All boilers having the same steam connections must be fired with the same coal. All coal must be weighed as it goes to the furnace. All cinders must be weighed as they leave the furnace. At the end of each shift all ash pans must be clean and fires clear and, as near as possible, in the same condition as at beginning of shift. Water level in boilers must be brought back to that at beginning of shift.

It is not usually practical to keep an accurate record of the weight of water actually evaporated. For this reason the amount of work done by the steam must be determined as carefully as possible. Records should be kept of the actual displacement of pumps, of suction and discharge pressures, and the work of all auxiliary machinery, heating appliances, etc.

Care should of course be taken that the stoking is done with discrimination so that each coal is fired to the best advantage. This caution is especially needed with mechanical stoking.

It is evident there are many variables to be considered in comparing one coal with another. It almost goes without saying that it will pay to design our coal handling plant so as to give every facility for keeping a clear record of each coal that goes through.

A system of inspection that includes effective sampling and laboratory tests is, of course, greatly to be desired, but unfortunately not often realized.

In closing we may say that determining the best system of coal handling for a pumping plant under given conditions is a problem of much complexity. The speaker hopes that the suggestions given herein may be of practical help to some who have such problems before them.

Mr. Thomas McMillan: We use hand-fired boilers. We have no automatic arrangement for handling coal. I think myself, from our experience, that there is a certain point in coal handling where a mechanical device pays; but up to that point I do not think it does pay. I should say that up at least to twenty-five tons a day there is no economy in automatic coal handling.

Several years ago we bought coal as low as $1.67 a ton, and that year we delivered water at the rate of 2.5 cts. per million gallons raised one foot high. This includes all pumping station expenses. I have failed to find in any report from other water works stations where they did any better than that. We have used the horizontal return tubular hand fired boiler, and from a previous paper you have learned some of the results we have had at the North Point Station. That has been done with a plain return tubular hand-fired boiler.

One gentleman asked about the advantages of a stoker. My own opinion is that there is no advantage in a stoker over a good fireman, any more than there will be some saving in the handling of the fuel to the furnace, but not in the actual results in the furnace. Of course we have no records to show a comparison between hand-fired and automatic stokers, because we have never used stokers; that is merely an opinion of my own.

President French: I would like to say a word with reference to stokers; I can't quite agree with the statement made by the gentleman from Milwaukee, that hand-firing gives better results. That may be true in one section, but there are so many other places where the facts are absolutely to the contrary that I cannot help but refer to it. We all know that in a hand-fired furnace of two hundred and fifty h.p., whether you use the best grade of anthracite coal or the best possible bituminous coal—you cannot force the boiler much beyond its commercial ratings. Yet if you go into some of the big power plants in the city here or elsewhere, you will find large stations being operated by mechanical stokers, especially street railway stations. In such stations it is the daily practice to force five hundred h.p. units up to eight hundred or nine hundred h.p. to meet the night and morning peak load of the service. We do not know what amount of money those same companies might have to spend to be prepared with extra boilers if they were not able to do that in order to meet the sudden calls upon them; it would be a tremendous amount. Within the last few months I have visited two big power stations in New York City, especially the one at 59th Street, the station where all the power is generated to operate the subway; and I made it my business to go there between the hours of five and six o'clock in the evening, just at the time when the peak load was coming on. They have there seventy two five hundred h.p. boilers; sixty-eight of these were running, and at about six o'clock when the full load was on, I do not think there was a boiler out of the whole sixty-eight that was not generating about eight hundred h.p. The chief engineer told me that it was not an uncommon thing to run them up to nine hundred h.p. for about two hours night and morning, just to meet that condition. Now that could not be done, of course, with any hand-fired mechanism, or with a flat grate, or with anything except a stoker grate. They have high stacks, something like two hundred feet, and the fireman is obliged to report on every shift just what draft he is using, taking the reading from a near-by draft gauge. I believe that the claim is that they get the best results on $\frac{5}{8}$ inch draft. I simply mention this to show that if they were not using mechanical stokers to meet those extraordinary conditions, they would have to have a much larger boiler space and a much greater investment.

MR. THOMAS MCMILLAN: I was not referring to general conditions, but merely local conditions, where our station is pumping into a reservoir, with a steady load during the twenty-four hours, throughout the week. My statement referred only to the local plant here, not the general conditions surrounding power stations or any other plants. I was merely stating the conditions as we have them in Milwaukee. We work our plant day after day and week after week with almost the same number of revolutions, the same amount of coal and draft. We do not require to speed up for any purpose. We may switch in an extra engine at times at certain seasons of the year, and so on; but our general conditions day after day are the same.

MR. GEORGE G. KENNEDY: Our conditions are the same. We run day after day without having a variation of over two or three revolutions. We are burning possibly a much cheaper coal than they are at Milwaukee. I think if you institute a comparison you will find we are doing it much cheaper than they are with their hand-fired boilers.

Mr. J. M. Diven: How does the cost at your station compare now, with stokers, with what it was before, with hand-firing?

Mr. George G. Kennedy. When we were using hand-fired boilers we were using other engines that were more expensive in regard to steam. We have only used the stokers with triple expansion engines, so that it is not possible for us to make any comparison there.

ACQUISITION BY NEW YORK CITY OF THE LARGER TWO WATER SYSTEMS OF STATEN ISLAND

BY LOUIS L. TRIBUS, M. AM. SOC. C. E.

Member of the Association

Staten Island, with an area of about 57 square miles, is shaped somewhat like the longitudinal cross-section of a pear, its two diameters being respectively a little less each than 15 and 8 miles, the longer pointing northeast and southwest.*

Politically, it is the county of Richmond, State of New York, and through the consolidation act is the Borough of Richmond of the City of New York.

Geologically, as far as present water sources are concerned, it belongs chiefly to the glacial period, though a ridge through a portion of the longer diameter is largely of serpentine rock and allied formations, while there is an outcrop in one locality, of practically a trap, locally called "syenitic"—a continuation of the Hudson Palisades. A small portion of the strata may have been detritus brought down by the Hudson River, but the greater portion is terminal moraine of the last glacial period; consequently, the boulders, sands and clays are very irregularly distributed both vertically and horizontally, making impossible any accurate calculation as to occurrence and flow of underground waters, and the area and shape of the island prohibit any extensive surface streams.

Topographically, some 6 or 8 square miles are covered with salt marshes; some 18 or 20 by more or less sandy level and rolling land; some 3 or 4 with fresh-water ponds, and the remainder, about 25 to 30, with rolling and hilly clay and hard pan areas;—the central ridge along the longer diameter rising to an elevation of over 400 feet. Under these conditions, rainfall very rapidly reaches the tidal waters surrounding the island, giving little opportunity for storage, surface or underground; at the same time there is a surprising quantity of water found in some of the sands, due most probably, to the existence of unseen glacial dams.

*See map which exhibits the following data also.

Staten Island has been thoroughly built up through a belt of from half a mile to two miles in width along the north and east shores for a length of about 10 miles, and over about one square mile at the southwestern extremity, with many scattered communities of a few hundreds each, along the transportation lines; the population today totaling about 80,000.

Some 30 years or so ago, the residents in the more thickly built-up portions felt the necessity of public water systems. It was before the days of municipal ownership, so private water companies were organized; one, the Staten Island Water Supply Company, taking for its territory the north shore of the island, another, the Crystal Water Company, occupying the east and part of the south shore. The other large community, that of Tottenville, did not rise to the occasion until some 15 years or so later.

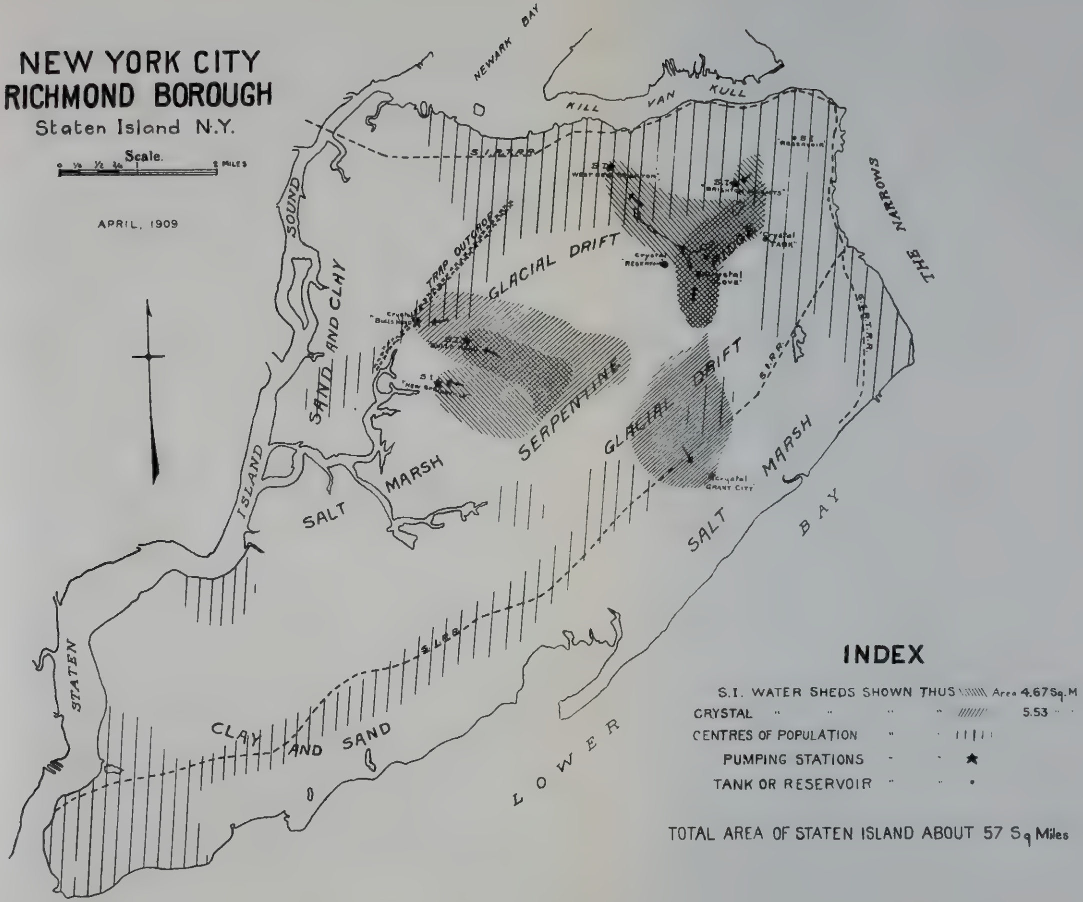
The Staten Island Water Supply Company, has, from time to time, enlarged its stations and installed additional ones until its plant at the time of New York City's final decision to acquire it, consisted of—

	Gallons.
4 Pumping Stations with gross daily pumping capacity of	13,350,000
Available daily average developed water supply of	4,350,000
Miles of cast-iron mains 4 to 24 inches in diameter	76½
Consumers (services)	5300

The Crystal Water Company went through a similar state of development, with a general holding as follows, viz:

	Gallons.
3 Pumping Stations with gross daily pumping capacity of about	8,000,000
Available daily average developed water supply of	2,970,000
Miles of mains, up to 20 inch diameter	56¼
Consumers (services)	2700

The village of Tottenville entered into a contract for the construction of village water works just prior to consolidation with New York City, so its plant became the first of the municipal water systems, and has been gradually extended to cover additional territory. There still remains one small water company in active business, operating in the district known as New Dorp, and another still smaller now acquired by the city but of no special importance or requiring description in this paper.



NEW YORK CITY
RICHMOND BOROUGH
Staten Island N.Y.

APRIL, 1909

After the city, through its appropriate departments and official boards decided that for the best interests of the borough, recourse should be had to municipal ownership so that the different plants could be operated to better advantage than under diverse private control, the question of the proper sums for payment became paramount. Naturally, the water companies desired to secure as large sums as possible and the taxpayers did not care to pay more than the plants were worth. There was no franchise value to be considered, and the companies having been in active operation for 20 to 25 years, during which time they had had opportunity to secure adequate returns on original investment, the problem became largely one of present worth of the physical plants and a certain "going concern" value, with perhaps a certain amount of "moral" asset to represent the city's ability to depreciate and destroy all earning power, through the possible paralleling of mains and the introduction of a new water supply. As a partial advantage to the companies, however, the local sources of water supply other than those owned by them were limited and for the current few years the city might not be in position to bring water from off the island, for two reasons; first, a contract entered into with a New Jersey corporation for a temporary supply had been tied up through litigation, though likely to be consummated in the end, and the supply from the Catskill Mountains now being secured for the whole city would obviously not be ready for some years.

When the writer mentioned earlier the non-existence of franchise rights, it is explained by the fact that the companies operated under the general incorporation laws of the State of New York, with nothing more than consents from the former village governments to lay mains in the streets, and through successive five-year contracts furnish water for fire protection, and at will, to residents for domestic or business purposes.

Another feature of interest in the proceedings was the doubt whether New York City possessed, in absence of special act, the power to actually condemn the plants and properties of the water companies, so that it was thought best and fairest to resort to an agreement if possible. A commission of engineers was appointed to represent the city, composed of the following men: Wm. H. Burr, I. M. DeVarona, Allen Hazen, J. Waldo Smith and Nelson P. Lewis.

Their report is taken as the basis for the herein contained data and estimates concerning the water plants. The writer, having other official city responsibilities which brought him frequently into relationship with the water companies, could not serve on the formal commission, but was in very close touch with its work and with the different engineering, legal and financial phases of the case from inception to final consummation, as well as having had full acquaintance, though not connection, with the plants from time of their original construction; these facts being the special warrant for his writing up the case and presenting it at this time.

The Staten Island Water Supply Company retained C. C. Vermuele as its engineering representative in all conferences: the Crystal Water Company accepted the valuations of the city's experts.

The water supplied by the two companies from their different plants varied very greatly in quality, all being derived from underground sources by means of driven wells ranging from some probably as shallow as 50 feet to others as deep as 150. One group of wells in particular, those at West New Brighton, showed an undue proportion of chlorine, indicating very clearly salt-water infiltration. The water from all of the wells of both companies possesses an excessive hardness, so in the engineer's report the companies were penalized, for hardness in excess of fifty parts per million, from $4 to $13 per million gallons of water pumped, and for salt and iron in the West New Brighton wells $10 per million in addition: another deduction for these latter wells was $20 per million for population on the tributary watershed, the water showing decided evidences of local contamination. The general price for water of a satisfactory standard was taken at $70 per million gallons, delivered in the distribution system under suitable pressure for domestic service. The deductions, therefore, made from the $70 price, brought the allowance for the different waters down to $66 for the best and $27 for the poorest. The method of arriving at the figures for deduction was the usual "soap softening" standard for hardness and "filtration" for population contamination. The "going concern" value was taken at $10 per service in use, representing about the average present value of the service connections from main to curb line.

In studying the proportions of different sized pipe in the distribution system, the excessive quantity of 4-inch is noteworthy in both companies, but especially in that of the Staten Island Water Supply plant. This can only be accounted for by the many extensions made from time to time, in short lengths, and without any comprehensive plan laid out for a harmonious or well-designed distribution system; the first thought apparently having always been, to secure the business in sight, at the least possible construction cost, without much regard to the fact that it entailed greatly increased pumping station expenses, due to unnecessary friction and caused a very serious diminution in fire pressure; first, due to inadequate mains, and second, to greater relative decrease in carrying capacity, from deposits and tuberculation.

For many years there had been continual differences between the companies and the people, over delinquencies in service and excessive charges; the latter would, with city ownership be cut to about one-third of the company rates, the former could by combining the different plants be very greatly bettered.

The balance of this paper will be largely tables of data and estimates, reshaped from the original reports, so as to present more clearly and in abbreviated form, the salient features used in the negotiations.

Estimates of Value of the Staten Island Water Supply Company's Plant—Based on Data Reported by the "Burr" Commission of Engineers.

YIELD AND VALUE OF WATER FROM THE DRIVEN WELL SYSTEMS.

Station.	Tributary drainage area as indicated by surface conditions, in square miles	Estimated yield in gallons daily.	Estimated value of the water as found in the wells per million gals.	Estimated cost of pumping per million gallons against about 150 lbs. pressure.	Assigned value of water as pumped, per million gallons.	Capitalized value of the water for 10 years at 5 per cent.*
West New Brighton	3.17	2,380,000	$6.30	$20.70	$27.00	$42,400
Bulls Head	0.61	1,170,000	42.80	23.20	66.00	141,000
New Springville	0.89	800,000	29.20	34.80	64.00	65,600
Totals and averages	4.67	4,350,000	$20.33	$23.96	$44.29	$249,000

*The 10 year figure is assumed as the time when Catskill water will be available for consumers, and as its quality is so much superior to the local waters, it would entirely supersede their use.

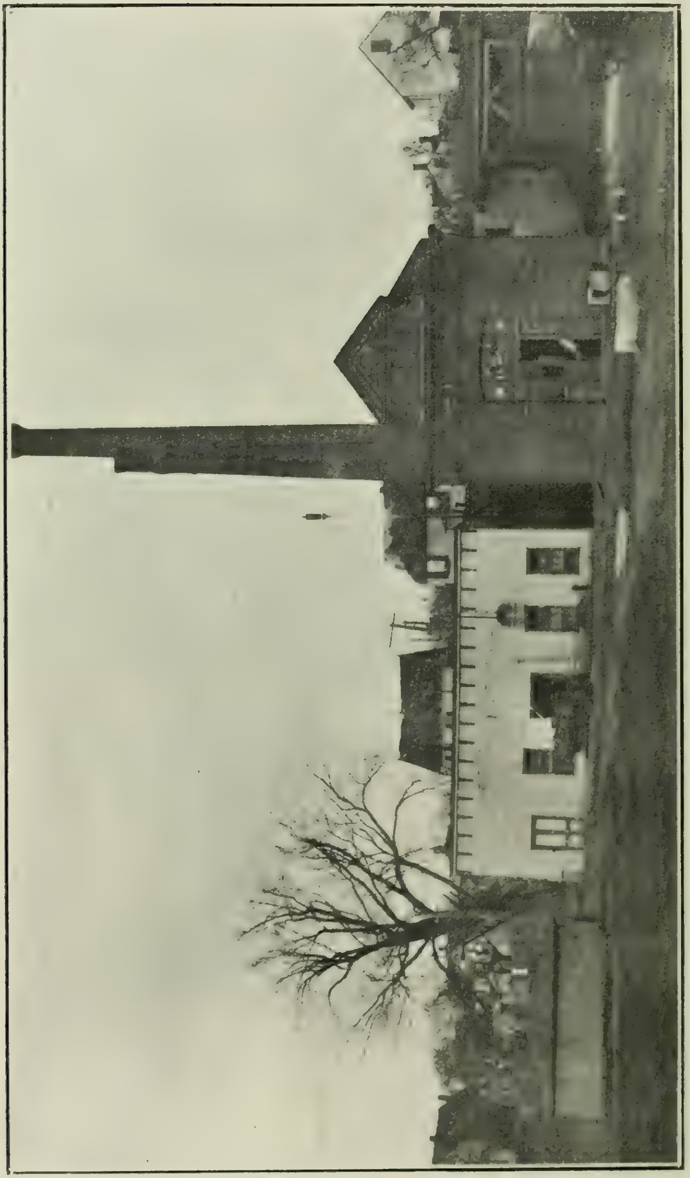


FIG. 1. WEST NEW BRIGHTON STATION, STATEN ISLAND WATER SUPPLY COMPANY

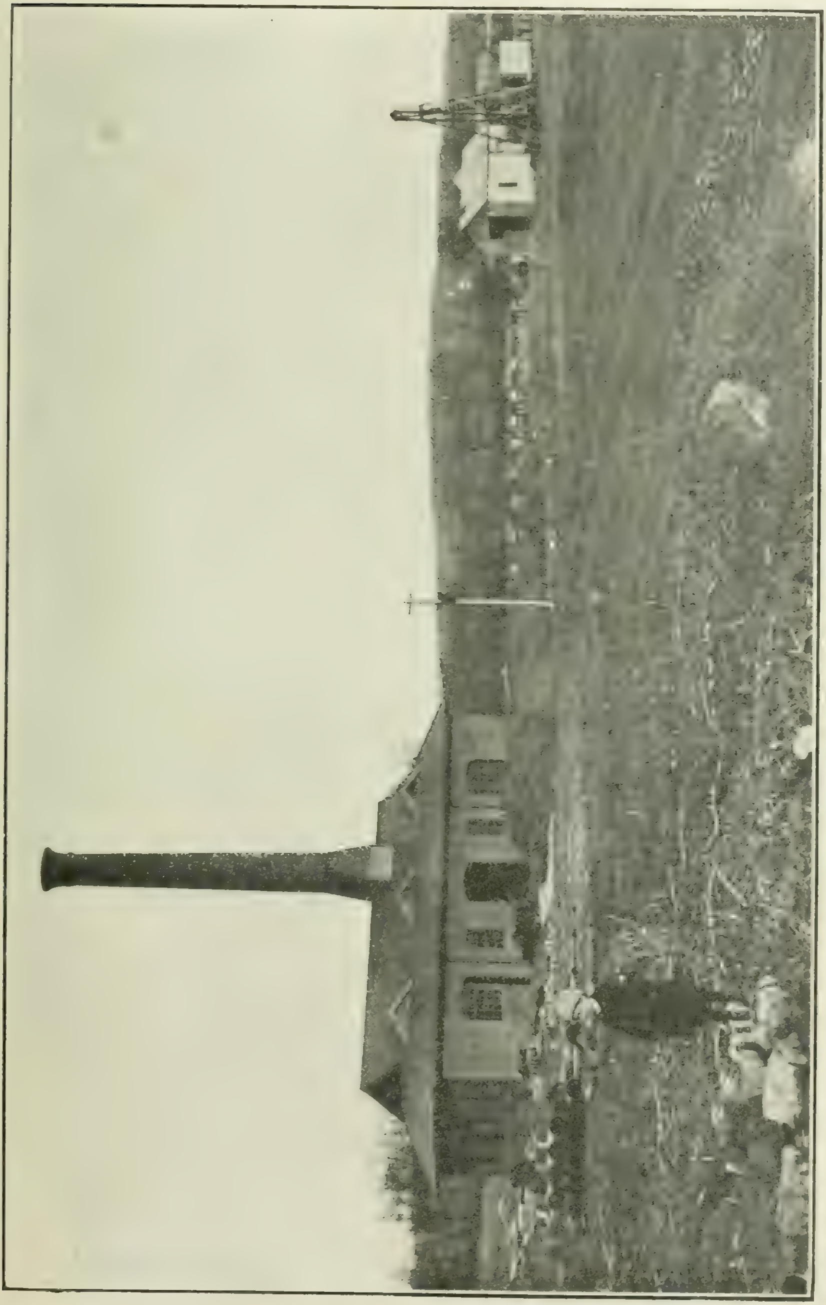


FIG. 2. BULLS HEAD STATION, STATEN ISLAND WATER SUPPLY COMPANY

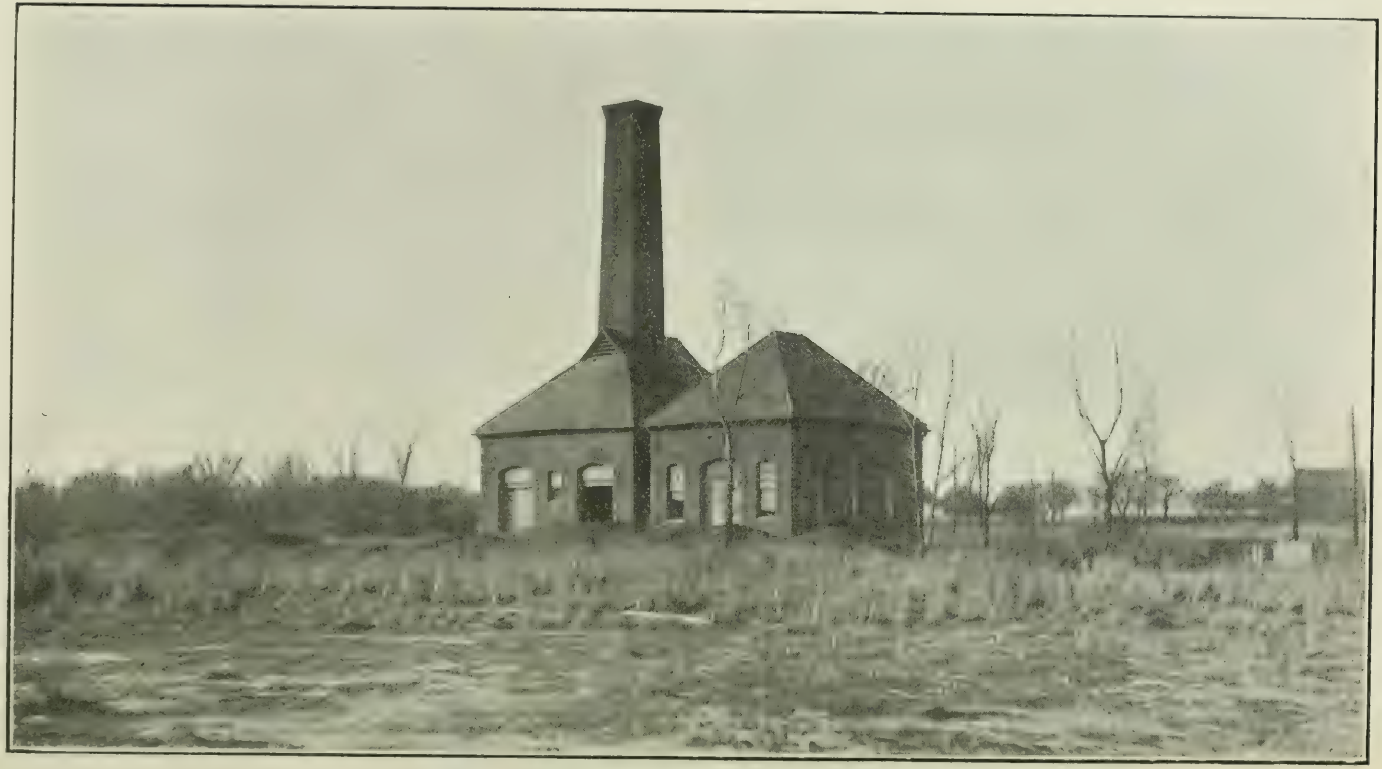


FIG. 3. NEW SPRINGVILLE STATION, STATEN ISLAND WATER SUPPLY COMPANY

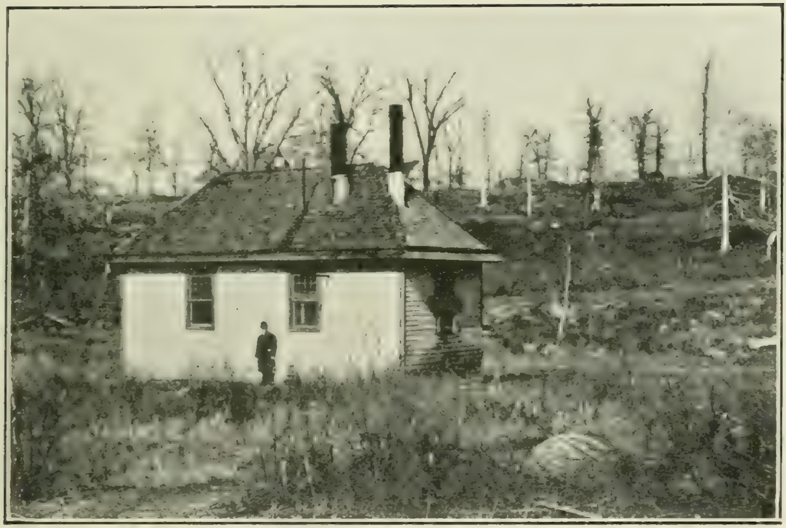


FIG. 4. BRIGHTON HEIGHTS STATION, STATEN ISLAND WATER SUPPLY COMPANY

Pumping Stations and Land.

STATION.	ITEM.	ESTIMATED COST	DEPRECIATION	RESULTANT VALUE.	TOTALS.	GRAND TOTAL.
West New Brighton (8½ million gallons gross pumping capacity (See Fig. 1)	Lands.........	$120,800	......	$120,800		
	Buildings......	20,310	$4,724	15,586	$136,386	
	Boilers........	9,400	4,360	5,040		
	Pumps........	43,100	14,800	28,300		
	Miscellaneous ..	12,350	2,410	9,940	43,280	
	Engineering, etc.........	10,210	......	10,210	10,210	$189,876
Totals		$216,170	$26,294	$189,876	$189,876	
Bulls Head (2½ million gallons gross pumping capacity) (See Fig. 2)	Land..........	$16,600	......	$16,600		
	Buildings......	18,000	......	18,000	$34,600	
	Boilers........	7,740	$240	7,500		
	Pumps........	12,000	120	11,880		
	Miscellaneous ..	4,050	......	4,050	$23,430	
	Engineering,etc.	6,215	......	6,215	6,215	$64,245
Totals		$64,605	$360	$64,245	$64,245	
New Springville (2 million gallons gross pumping capacity) (See Fig. 3)	Land..........	$6,600	......	$6,600		
	Buildings......	13,500	$1,100	12,400	$19,000	
	Boilers........	6,000	600	5,400		
	Pumps........	13,000	2,600	10,400		
	Miscellaneous ..	100	......	100	15,900	
	Engineering, etc...........	4,245	......	4,245	4,245	$39,145
Totals		$43,445	$4,300	$39,145	$39,145	
Brighton Heights (350,000 gallons gross pumping capacity) (See Fig. 4.)	Land	$1,000	......	$1,000		
	Building.......	800	$80	720	$1,720	
	Boiler.........	750	150	600		
	Pump..........	600	180	420	1,020	
	Engineering, etc..........	260	......	260	260	$3,000
Totals......................		$3,410	$410	$3,000	$3,000	
Grand totals, all stations........		$327,630	$31,364	$296,266	$296,266	$296,266

Suction and Distribution Mains—About 76 3/5th Miles.

SIZE DIAMETER IN INCHES	LENGTH IN FEET	PERCENTAGE OF TOTAL LENGTH	ESTIMATED COST	PERCENTAGE OF DEPRECIATION 5 TO 25 YEARS IN USE	RESULTANT VALUE.	TOTALS	GRAND TOTALS
14 to 24	6,460	1.6	$15,990	10	$14,392		
10 and 12	40,889	10.2	66,384	10	59,747		
8	16,657	4.1	18,456	10	16,611		
6	124,689	31.0	99,950	15	85,094*		
4	213,811	53.1	128,381	50	64,323*	$240,167	
Totals.	402,506	100.0	$329,161	..	$240,167		

*A trifle less depreciation than 15 and 50, charged for about 4000 ft. total of 4″ and 6″ pipe.

983 4″ to 24″ gates			$10,461	..	$10,461		
602 fire hydrants			24,080	10	21,672		
24 crane hydrants			3,360	10	3,024		
10 drinking hydrants			200	10	180		
159 meters			2,385	..	2,385	$37,722	
3500 cubic yards rock excavation			10,500	..	10,500		
130,000 square yards pavements relaid			91,950	15	78,158	88,658	
Engineering and contingencies			54,982	..	54,982	54,982	
Totals			$197,918	..	$181,362	$181,362	$421,529
Grand Totals			$527,079	..	$421,529	$421,529	$421,529

Reservoirs and Land.

Small equalizing reservoir at New Brighton (see Fig. 5)	$4,000	..	$4,000		
Land for same	5,200	..	5,200	$9,200	
Engineering and contingencies	1,380	..	1,380	1,380	$10,580
Totals	$10,580	..	$10,580	$10,580	$10,580

Summary of Estimates.

10 years' value of water available	$249,000
Pumping Stations and Lands	296,266
Pipe System	421,529
Reservoir and Land	10,580
Going concern value (5300 services at $10.00)	53,000*
Total	$1,030,375

* Not scheduled elsewhere.

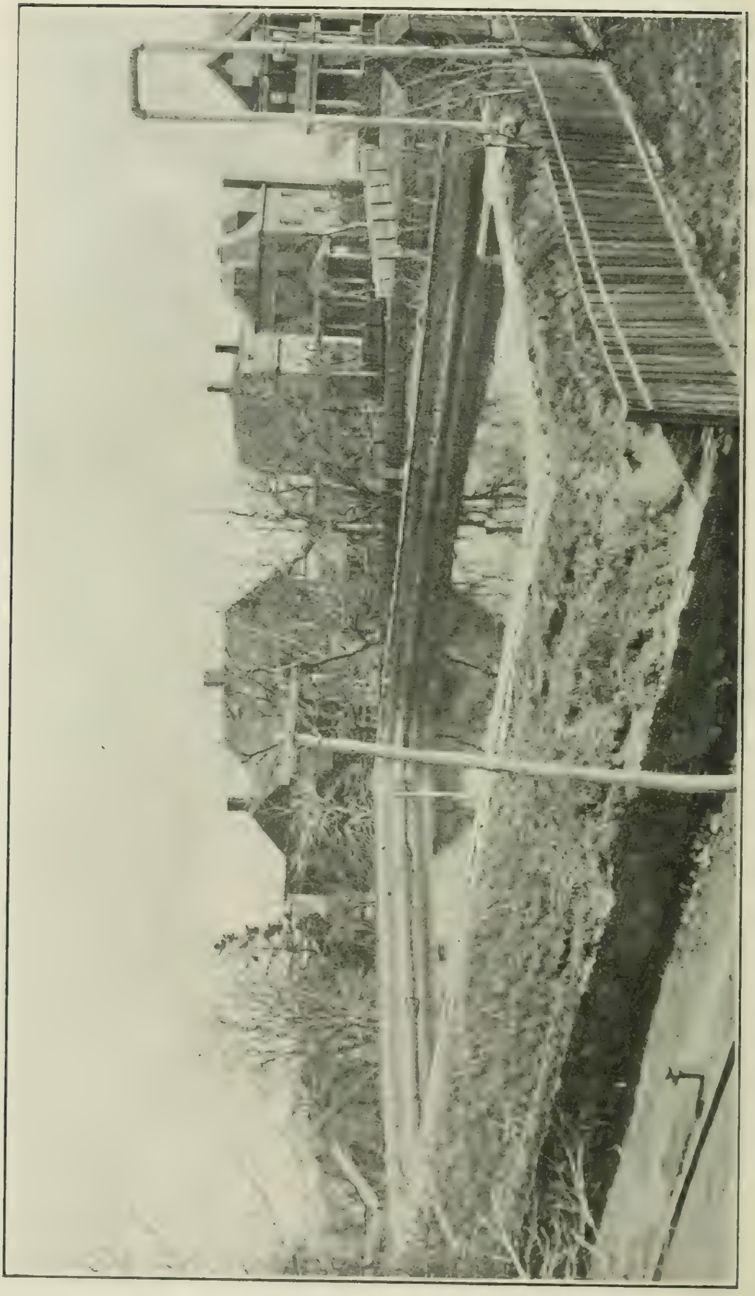


FIG. 5. NEW BRIGHTON RESERVOIR, STATEN ISLAND WATER SUPPLY COMPANY

The original Engineering Commission, however, did not use these figures for other than a guide, but felt that some of the allowances were too great, so based its report on the following data, considering the plants (except for distribution system) as likely to be abandoned at end of ten (10) years. With this idea in mind the value became more one of salvage and 10 years' worth of water as delivered in the mains, the machinery being estimated as likely to be practically worthless at end of the period.

Water (Capitalized for 10 years) and Salvage Values.

TOPIC.	WEST NEW BRIGHTON STATION.	BULLS HEAD STATION.	NEW SPRINGVILLE STATION	BRIGHTON HEIGHTS STATION.	TOTALS.	GRAND TOTALS.
Present value of water, less cost of pumping, for 10 yrs..........	$42,400	$141,000	$65,600	......	$249,000	
Salvage value of property at 200 per cent of assessed valuation of land (as of 1905 without improvements..............	120,800	16,600	6,600	$1,000	145,000	
Structures, pump, etc..	......	......	......	2,000	2,000	$396,000
Totals for water supply...............	$163,200	$157,600	$72,200	$3,000	$396,000	

Distribution system—less suction and well lines (included in value of water)..	$413,273
Going concern value (5300 services at $10)........................	53,000
Total approximate value....................................	$862,273

Capacity of sources: 2.00 million gallons per day of "good" water.
2.35 million gallons per day of "poor" water.

Total..........4.35 million gallons.

It would be quite possible, with full warrant for so doing, to vary the estimates very greatly and show totals ranging from $800,000 to $1,300,000.

After the Commission presented its report the Staten Island Water Supply Company desired to have a special arbitration board of engineers, to go over the whole matter, though it did not agree to abide by the decision of such a board: the city, willing to do everything in full fairness, consented, and Allen

Hazen, C. C. Vermeule and Morris Sherrerd were chosen, the last named selected by the former two. They agreed upon a value for the physical plant and "going concern" condition as follows:

Lands, reservoirs, buildings, machinery, pipe lines, etc.	$837,000
"Going Concern" value	70,000
Total	$907,000

They did not, however, agree upon the water rights, estimating them variously as worth from $300,000 to $570,000.

As a result of further conferences between the city officials and representatives of the water company, and a final and arbitrary stand by the city that it would pay a certain sum of money and no more, the company finally decided to accept $1,100,000 rather than meet the otherwise inevitable result of having its mains paralleled and its business absolutely ruined. In this figure the company received fair treatment. It had earned enough in its nearly thirty years of operation to have paid its investors handsomely had there not been waste in construction and operation. Even with that, however, the sum awarded represents fairly a return of the invested capital and reasonable profit upon it.

Estimates of Value of the Plant of the Crystal Water Company, Based on Data Reported by the "Burr" Commission of Engineers.

YIELD AND VALUE OF WATER FROM THE DRIVEN WELL SYSTEMS.

Station.	Tributary drainage area as indicated by surface conditions, in square miles.	Estimated yield in gallons daily.	Estimated value of the water as found in the wells per million gals.	Estimated cost of pumping per million gals. against heads of 75 to 140 lbs.	Assigned value of water as pumped, per million gals.	Capitalized value of the water for 10 years at 5 per cent (see note in S. I. W. S Co. estimate).
Clove	1.30	970,000	$42.30	$20.70	$63.00	$101,000
Bulls Head	2.45	1,000,000*	23.00	40.00	63.00	50,000
Grant City	1.78	1,000,000*	36.10	27.90	64.00	74,500
Totals and averages	5.53	2,970,000	$33.71	$29.62	$63.33	$225,500

*These territories are not fully developed; hence the yield assigned is small.

Pumping Stations and Lands.

STATION.	ITEM.	ESTIMATED COST.	DEPRECIATION.	RESULTANT VALUE	TOTALS.	GRAND TOTALS.
Bulls Head (2½ million gallon gross pumping capacity) (See Fig. 6.)	Lands.........	$15,370	......	$15,370		
	Buildings......	9,100	$3,690	5,410	$20,780	
	Boilers........	3,300	1,390	1,910		
	Pumps........	4,010	497	3,513	5,423	
	Engineering, etc...........	1,625	....	1,625	1,625	$27,828
Totals......................		$33,405	$5,577	$27,828	$27,828	
Clove (4 million gallons gross pumping capacity) (See Fig. 7.)	Lands.........	$42,000	......	$42,000		
	Buildings......	13,300	$3,660	9,640	$51,640	
	Boilers........	4,000	1,040	2,960		
	Pumps........	6,320	2,440	3,880		
	Miscellaneous ..	625	......	625	7,465	
	Engineering, etc...........	2,566	......	2,566	2,566	$61,671
Totals......................		$68,811	$7,140	$61,671	$61,671	
Grant City (New station not quite completed, about 1½ million gals. daily capacity. (See Fig. 8.)	Lands.........	$6,700	......	$6,700		
	Buildings......	3,070	......	3,070	$9,770	
	Boilers........	2,375	......	2,375		
	Pumps........	4,230	......	4,230		
	Well Driver and Engine......	650	$130	520	7,125	
	Engineering....	1,529	......	1,529	1,529	$18,424
Totals......................		$18,554	$130	$18,424	$18,424	
Grand totals, all stations..........		$120,770	$12,847	$107,923	$107,923	$107,923

Suction and Distribution Mains: about 56¼ Miles.

SIZE, DIAMETER IN INCHES Wrought iron.	Spiral riveted.	Cast iron.	Length in feet.	Percentages of total length.	Estimated cost.	Percentages of depreciation, 5 to 23 years in use.	Resultant value.	Totals.	Grand total.
6	....	.....	1,875	0.6	$2,062	10	$1,856		
3½ & 4	....	.....	8,640	2.9	5,248	50	2,624		
1, 1½ & 2	....	.....	21,210	7.1	7,424	50	3,712		
	12	.....	3,550	1.2	4,082	50	2,041		
	6	.....	6,800	2.3	3,740	50	1,870		
	....	14 to 20	10,479	3.5	24,828	10	22,347		
		10 to 12	42,720	14.4	75,143	10	67,629		
		8	18,050	6.1	19,987	10	17,989		
		6	89,472	30.2	71,709	10	61,015		
		4	94,095	31.7	56,481	30 to 50	28,270	$209,353	
Totals			$296,891	100.0	$270,704	..	$209,353		
420 4″ to 20″ gates					$5,036	..	$5,036		
453 fire hydrants					18,120	10	16,312		
37 crane hydrants					2,590	10	2,331		
10 drinking hydrants................					200	10	180		
2197 meters					26,985	about 10	24,585	$48,444	
5000 cubic yards rock excavation					15,000	..	15,000		
100,000 square yards pavements relaid					70,400	15	59,840	74.840	
Engineering and contingencies					49,895	..	49 895	49,895	$382,532
Totals					$188,226	..	$173,179	$173,179	
Grand totals					$458,930	..	$382,532	$382,532	$382,532

Reservoirs and Lands.

70,000 gals. elevated tank (see Fig. 9)	$4,000	20	$3,200		
Land for tank	1,000	..	1,000	$4,200	
4 million gal. reservoir (see Fig. 10)	7,000	50	3,500		
3 acres land for reservoir	6,000	..	6,000	9,500	
Engineering and contingencies	2,055	..	2,055	2,055	$15,755
Totals	$20,055	..	$15,755	$15.755	$15,755

Summary of Estimates.

10 years' value of water available	$225,500
Pumping Stations and Lands	107,923
Pipe System	382,532
Reservoirs and Lands	15,755
Going Concern Value (2700 at $10.00)	27,000*
Total	$758,710

* Not scheduled elsewhere.

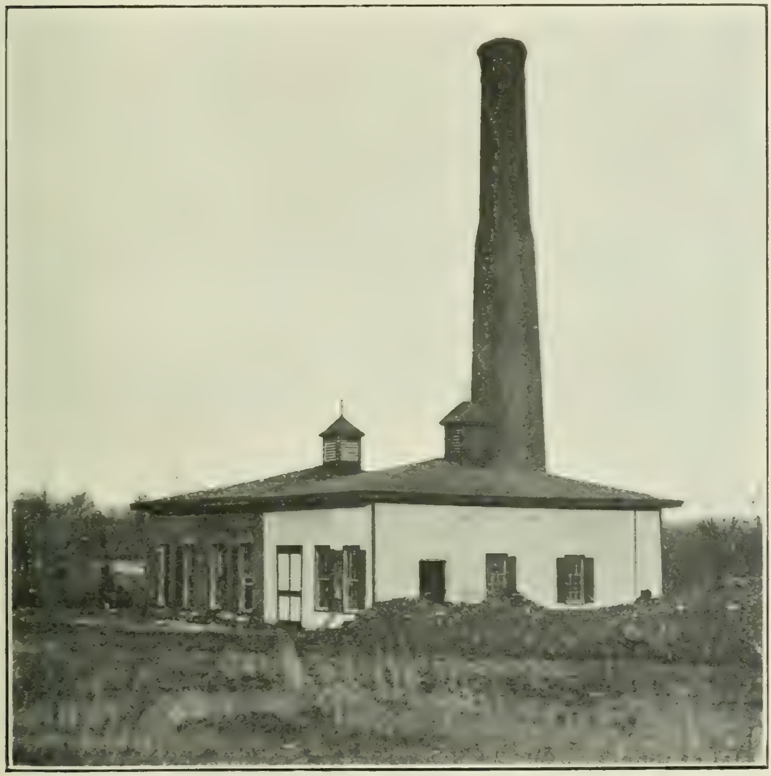


FIG. 6. BULLS HEAD STATION, CRYSTAL WATER COMPANY

Here again the Commission felt that, as in the case of the Staten Island Water Supply plants, the water and salvage values made the better basis for purchase, so estimated the case as follows:

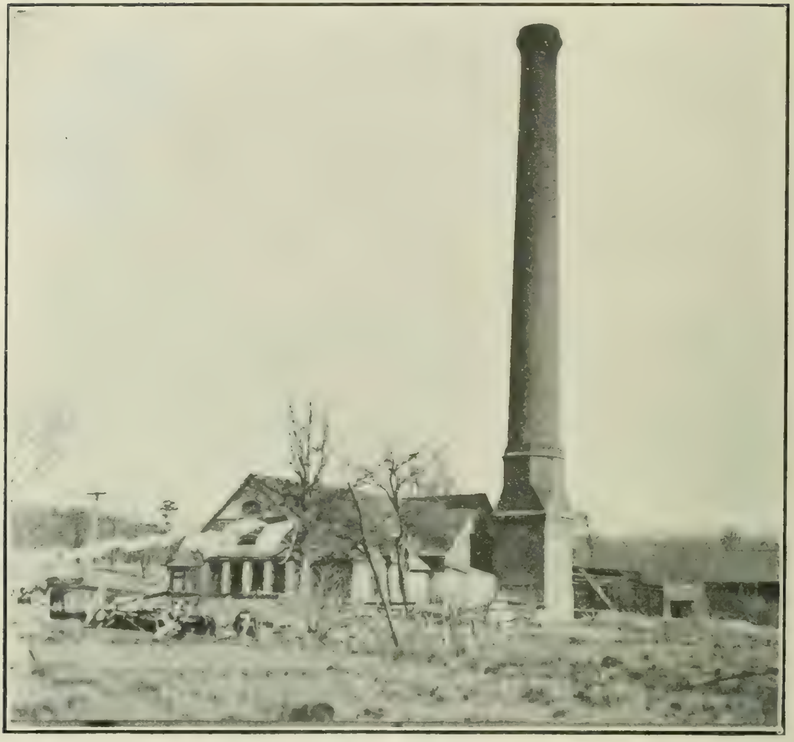


FIG. 7. CLOVE STATION, CRYSTAL WATER COMPANY

Water (Capitalized for 10 years) and Salvage Values.

TOPIC.	BULLS HEAD STATION.	CLOVE STATION.	GRANT CITY STATION.	TOTALS.	GRAND TOTALS.
Present value of water, less cost of pumping, for 10 years........	$50,000	$101,000	$74,500	$225,500	
Salvage value of property at 200 per cent of assessed valuation of of land (as of 1905) without improvements..................	15,370	42,000	6,700	64,070	$289,570
Totals for water supply......	$65,370	$143,000	$81,200	$289,570	

Distribution system—less suction and well lines (included in value of "water")...	$392,819
Going concern value (2700 services at $10).........................	27,000
Total approximate value....................................	$709,389

Capacity of sources—2.97 million gallons per day of "good" water.

The plant of the Crystal Water Company showed to better advantage than the other, but here also lack of comprehensive design was evident; but the water itself is of materially better quality.

After the commission of engineers presented its report, a conference committee succeeded in arranging with the Company for the acquisition of its property and rights, without much difficulty at practically the Commission's own figures of about $710,000 plus value of certain improvements in progress, and interest, from July 1, 1906, to date of taking.

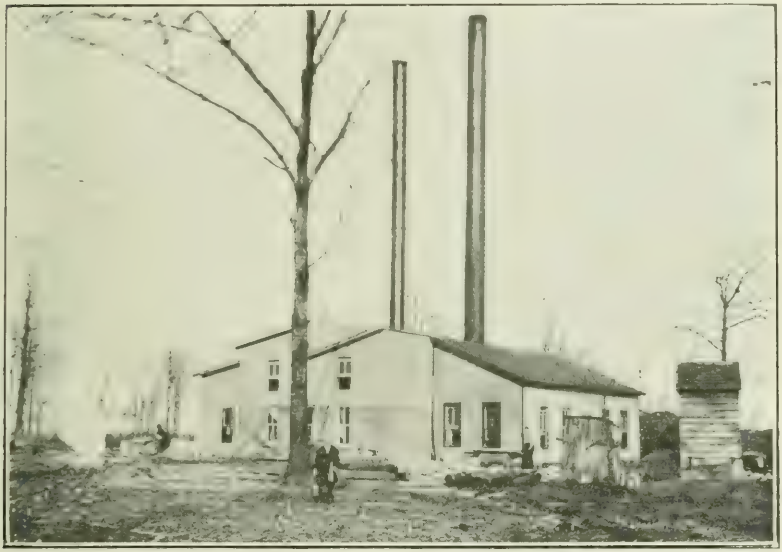


FIG. 8. GRANT CITY STATION, CRYSTAL WATER COMPANY

This figure represented a fair return on a reasonable investment, but did not net much profit to the original bondholders, as they lost a large sum of money through the laying of many miles of spiral riveted pipe, poorly placed, so that much of it had to be entirely renewed, that whole cost being practically thrown away. Of course, the city could not take such a condition of affairs into consideration in buying the existing plant, so that while the purchase price is fair for present-day conditions, the original investors have not fared so well as have those of the Staten Island Water Supply Company.

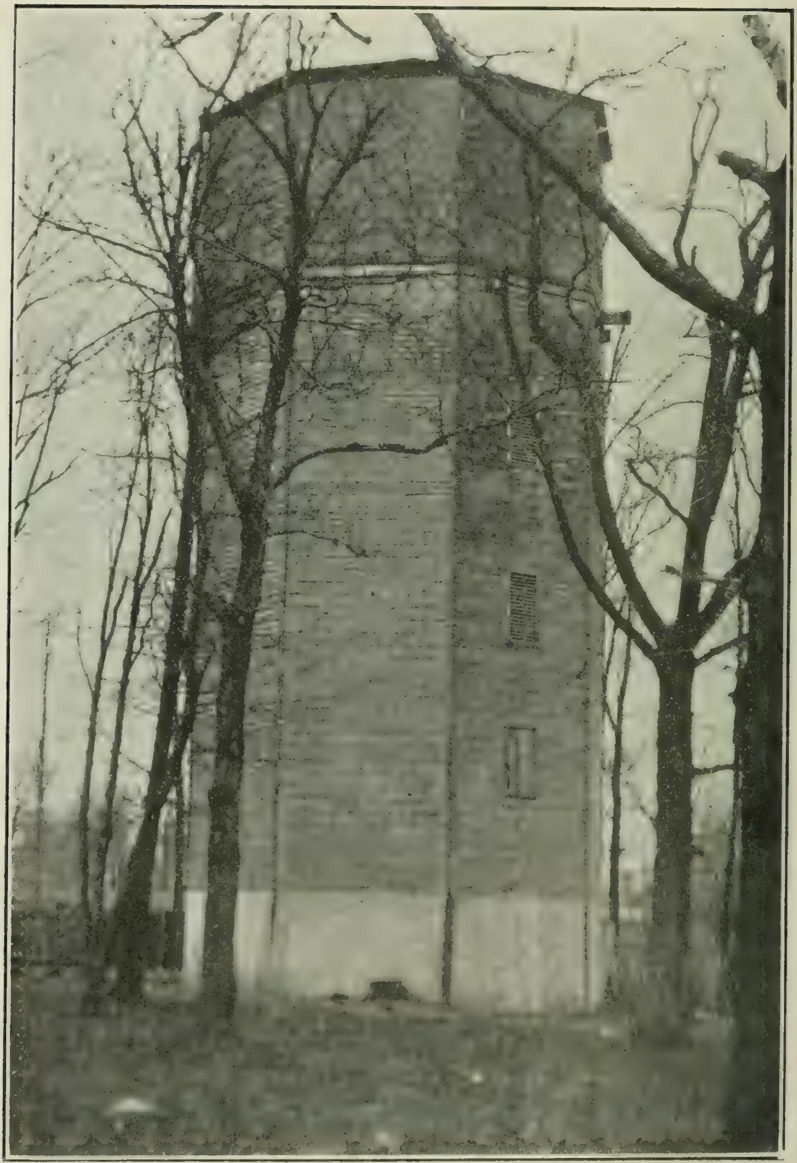


FIG. 9. ELEVATED TANK, CRYSTAL WATER COMPANY

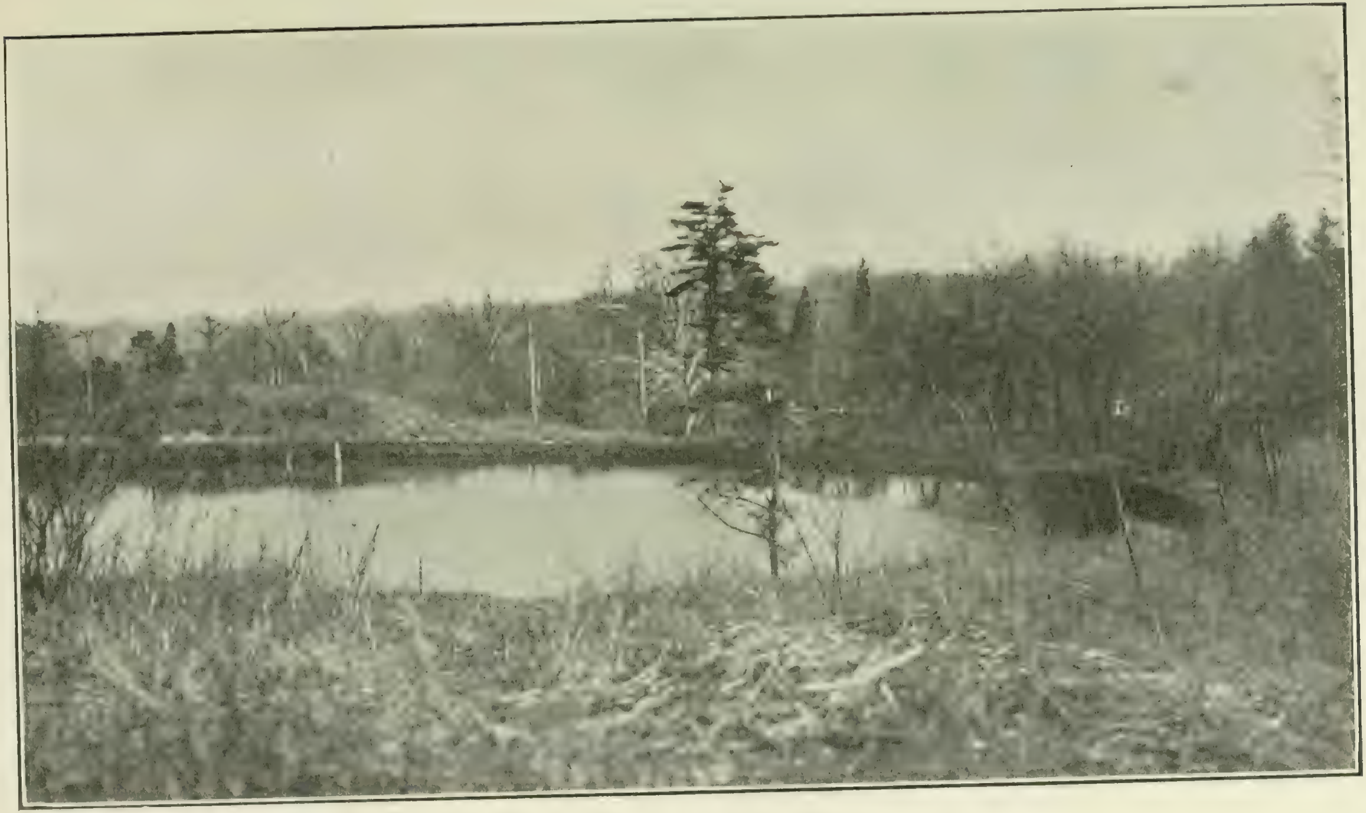


FIG. 10 CIRCULAR RESERVOIR, CRYSTAL WATER COMPANY

DISCUSSION

Mr. Edward W. Bemis: May I ask what would happen if the Jersey Water Company should fail to deliver a sufficient supply? Has the city of New York any other sources of supply that they could bring to bear?

Mr. Nicholas S. Hill, Jr.: I think the ultimate solution of the problem will be when the new Ashokan dam is built and there are pipe lines from it to Brooklyn. As soon as the dam is built a submarine pipe will be laid from the Brooklyn shore across to Staten Island, and Staten Island will be included in this supply from the Catskill region. That of course is the ultimate development. It has become imperative that the Water Department of New York should provide a tentative supply for the Island, and the contract made with the New York & New Jersey Water Company was made on the supposition that the city would be in a position in some ten or twelve years to have an abundant supply brought across the Narrows in the way outlined.

A Member: Would it be an engineering possibility, to bring a submarine line across from Brooklyn.

Mr. Nicholas S. Hill, Jr.: I think so.

A Member: What is the distance from Brooklyn to Staten Island?

Mr. Nicholas S. Hill, Jr.: About one mile.

A Member: About what is the depth of the water?

Mr. Nicholas S. Hill, Jr.: I should say that the water there was about forty to fifty feet deep.

Mr. J. M. Diven: What would be the objection to carrying the pipes overland, through Jersey City?

Mr. Nicholas S. Hill, Jr.: It will be cheaper to build a short line across the Narrows than to build special pipes through New Jersey to supply Staten Island.

Mr. J. M. Diven: Do you know how that allowance of $10 for services was arrived at?

Mr. Nicholas S. Hill, Jr.: There have been several cases in New Jersey where that figure has been adopted. Why, I do not know.

Mr. J. M. Diven: I understand that $10 was added for each service as going value.

Mr. Nicholas S. Hill, Jr.: I could not say as to that.

A MEMBER: Is it not possible that that $10 represents approximately the average annual revenue? I know with the Lighting Companies one year's revenue is not infrequently used as an addition for going value.

MR. NICHOLAS S. HILL, JR.: In this connection I might say that I had nothing whatever to do with the valuations of these properties The valuations were made by a committee appointed by Mayor McClellan. The Committee consisted of the following gentlemen: Nelson P. Lewis, J. Waldo Smith and Allen Hazen. I think Mr. C. C. Vermeule was employed by the Staten Island Water Company to represent their interests, and the Crystal Water Company left the whole matter to the commission appointed by the city.

A MEMBER: Do you know what their gross annual revenue was?

MR. NICHOLAS S. HILL, JR: No, I have not the figures.

A MEMBER: Had the companies been making money or not?

MR. NICHOLAS S. HILL, JR.: I think they were on a paying basis and that the Staten Island Company had paid a fair return for some years past.

MR. J. M. DIVEN: I think Mr. Tribus answered that question in his "Summary of Estimates."

AN OUTBREAK OF TYPHOID FEVER DUE TO MILK

PROF. ERASTUS G. SMITH, PH.D.

In the early summer of 1906 an outbreak of typhoid fever occurred at Beloit, Wis., which as far as I am informed has never been described. Fortunately the outbreak was limited to a comparatively few cases; the period of the outbreak was brief, and rapidly passed away. The first cases were reported on April 26, 1906; another case in the same family, April 28; two cases in another family, April 26; another, April 30; another, May 2; two cases, May 7, and one, May 9. Naturally public attention was called to this repetition of the disease, and as a result a great deal of anxiety and fear arose.

It was perfectly evident that these cases must have had some cause in common, and it fell to the writer to carry out inquiries into the outbreak. Rumors came rapidly of numerous cases throughout the city, many of them separated from each other by a considerable distance; but investigation eliminated all but those cited above. There were at the same time other cases in the city; it proved however that one of them was a man who had been taking care of his brother, sick with the disease in Milwaukee; the other a person who had been sick for several weeks. The outbreak was typical of the disease. The victims, one and all, were violently ill with the symptoms characteristic of the disease. It was of an abnormally virulent type, as out of eleven cases three died after about four weeks, and all of the others were ill for a long period. The virulence of the disease was most marked.

The cause of this outbreak is what particularly interests us tonight. All of the cases were either young children or persons who used milk as a considerable article of their diet. It was perfectly evident that there must be something in common, and naturally the first thought was regarding the water supply of the city of Beloit. The investigation therefore taken up at the request of the health officer and the management of the water company sought to study all possibilities of the cause for the disease, and the conclusion arrived at was by the method of eliminating one after the other of possible causes of contamination.

First, as to the water supply. The city of Beloit is situated in southern Wisconsin, near the state line, about ninety miles northwest of Chicago. It is on either bank of the Rock River; the main part of the city being upon the high gravel bluff lining the river. The water supply is taken from three different sources, the main station being on the left hand bank of the river, the water being derived from a large well thirty feet in diameter and thirty feet in depth. Into the bottom of this well are driven a series of drive points reaching to considerable depths into the gravel sub-stratum.

The second supply is derived from the so-called West Side, from a series of drive points driven to a depth of about one hundred feet into the gravel sub-stratum. These points penetrate a series of thin layers of hard, water-tight, compact hard pan, which effectually cuts off all possibility of surface contamination.

A third well has been driven on the East Side at the electrical pumping station, which supplies a small quantity of water. The writer has made numbers of analyses, during the last twenty-five years, and has found the quality always good, quite uniform, and with no evidences of sewerage contamination. Careful analyses, both chemical and bacteriological were made at the time of this outbreak, and the water found in quite normal condition, without any evidence whatever of any pollution.

It will be noted that the cases are in one section of the town. The student of sanitary science will at once note that such a distribution of cases would be extremely improbable were the water supply responsible for the disease. The cases would have been located probably nearer the central stand pipe, or distributed throughout the city, instead of being located as they were in one section of the town.

Secondly, no contaminated well could have caused this outbreak, as none of the houses where the cases occured has a well; in fact there are but very few wells in the section of the city where the outbreak occurred, all of the houses practically throughout the section being supplied with water from the public supply.

Third, the miscellaneous contaminating influences, such as the so-called "comrade" infection, oysters, unwashed fruits and vegetables, flies, must be eliminated, as the families involved had little to do with each other, and it was not the season for oysters, or fruits, or flies.

The other possible source of the disease is milk; an investigation showed that all of these families took milk from the same milkman. Further, the outbreak was characteristic of a milk outbreak rather than a water borne infection. The suddenness of the outbreak, the briefness of its duration, the virulence of the disease as it developed and progressed, all are characteristic of a milk borne contagion.

I regret that the specific cause of this probable infection of the milk could not be worked out further. The owner of the milk route had a new dairy, with a new cemented milk house; and extreme care had been used to deliver a clean wholesome milk supply. I was informed by him that he occasionally bought cans of milk to supply his customers when his own supply was short; and in my best judgment one of the cans thus bought supplied the source. It seems to me that in all probability this difficulty arose from a single can of milk which by some possibility had become infected through some case of walking typhoid. At any rate I submit this evidence, appearing as it does to me to be a clear case of an outbreak due to infected milk.

I have submitted this paper to this convention for four distinct reasons, viz:

(1) Because the outbreak interested me personally, and was the first instance in my practice where an outbreak was clearly attributable to infected milk.

(2) Because the method employed in the study of the case might be helpful to others.

(3) In order that water works' managers, who are so largely represented here tonight, might be stimulated to investigate cases of typhoid fever. The responsibility is upon them in the case of this filth disease to determine whether the water supply is responsible for the spread of the disease, or whether the disease can be attributed to other causes, and finally,

(4) In order to awaken a new interest in the sanitary features involved, so that the public exposed as it is to the disease from many sources, may be saved as far as possible from the evil consequences of them.

DISCUSSION

Mr. H. F. Dunham: Can you tell us what is the usual number of typhoid fever cases there per year?

Prof. E. G. Smith: Very small. We have typhoid fever a good deal there, but have never had a case associated with the water supply. They have been accounted for in other ways. This section (indicating on slide) has a lot of mean low service wells. I have seen at this point a well sixteen feet deep, surface well, because this is down near the water level, with a privy vault which was used by a boarding-house of thirty-five people, nine feet away from it filled to the brim. Can anyone wonder why they had this diarrheal disease? We have in here these low service wells, Third street and Fourth street, on the bench up from the river. We have never had typhoid fever back here on this high line except some imported cases. We are apt to have them all the time because of our large floating population. There is no reason why the water supply should communicate it because their wells are deep driven wells and are well protected.

Mr. H. F. Dunham: Did you pursue the question as to where the cans of milk came from?

Prof. E. G. Smith: I could not find that out.

Mr. R. M. Downie: I am very much interested in this discussion. If you will allow me two or three minutes I will give you the history of a case in western Pennsylvania. An epidemic of typhoid fever broke out some four years ago at Butler, Pa., and the State Board of Health took the matter up and investigated it. They found that the primary cause of contamination was an isolated case of typhoid fever on the water shed of the reservoir. The water is pumped there from Connoquenessing creek. The water shed is about one-half to three-fourths of a mile in diameter, from which drainage comes into the reservoir. On the water shed there was a house in which a case of typhoid fever occurred which was the primary source of contamination. When the city water was shut off and the mains cleansed, the epidemic did not subside. About thiriy-six hundred cases of typhoid fever developed in the course of about sixty days. It was a very mild form of the disease, and the death rate was low. Many of the people who were suffering from it were able to be about, and frequent the saloons.

They have a car works there employing a great many foreigners, some thirty-six hundred to four thousand of them working in the car works, and they are a little careless or ignorant of sanitary laws. As soon as they got the fever many of them would break for the saloons in order to keep up their spirits; and the main cause of contamination was found to be in the saliva that stuck to the beer glasses. These beer glasses were washed in tubs under the bars, and it was finally discovered that these tubs were wholesale culture vats for the fever germs and the chief cause of contamination. That is a very interesting circumstance.

I am located in the town of Beaver Falls on the Beaver River, which receives water from the Connoquenessing Creek and, of course, we received sewage from the town of Butler. We were all excited about the epidemic and resorted for the time being to boiling the water. There was no spread of the disease to other towns.

There was a case in Washington County, Pa., a few years ago, where a typhoid fever patient before thoroughly convalescent milked the cows and lowered the milk into an open, or old fashioned dug well for the purpose of keeping it cool. A little later on the man of the household was taken down with typhoid fever, and perhaps thirty or forty neighbors gathered in to help him with his farm work. A few days before this "frolic" occurred, the string broke that held the bucket of milk in the well and its contents were emptied into the water. On the day of the frolic the men drew water from this well. All of them drank from it with the exception of one man. Later on every single man who was at that "frolic" or husking bee, or whatever it was, was taken down with typhoid fever, except the one who did not drink from that well. It was a clear case of contamination from milk drawn from a cow by a convalescent patient and then precipitated into the family well.

A few years ago an outbreak of typhoid fever at Plymouth, Pa., was finally traced to contamination from a single case of typhoid fever located on the water shed of the water works. It actually contaminated the whole city. There were probably a thousand cases there. I have been exceedingly interested in this discussion, because I know that frequently water works men are blamed. Sometimes they are guilty, sometimes not.

Mr. W. H. Winslow: We had a typhoid epidemic caused by milk in Superior about two years ago. As daily bacteriological examinations of our water supply were being made, the water supply was not under suspicion when they started the investigation, and attention was immediately directed to the milk question. They found that substantially all of the cases took milk from one man. I think there were thirty of them. They went out to this dairy and found that the man who was milking the cows had just been discharged from the hospital as cured of typhoid fever. The whole thing was over in about two days as far as additional cases were concerned; but unfortunately there were quite a number of deaths.

Prof. E. G. Smith: Typhoid fever which originates from contamination of the water supply, comes on rather gradually and is not so severe a type; but that which comes from milk contamination comes on suddenly and severely.

Mr. W. H. Winslow: As I recall it the cases at Superior came on one after another extending over a period of about fourteen days, showing that the man who had been contaminating the milk had practically worked right along, but as soon as he was taken off the job the trouble was all over.

Mr. E. W. Bemis. I think we all will be interested in the diagrams that will appear in my report for the calendar year, 1908, presenting a study of cases of a very moderate amount of typhoid fever that we still continue to have in Cleveland after the extension of the intake. It is very moderate, for the average number of deaths per 100,000 based upon the United States Census estimate of population was only seventeen, the average for the last four years, In fact last year it was only about thirteen, so that we ranked eleventh among the fifty largest cities last year, only ten being better.

I was quite impressed in talking that over, with suggestions made to me by Mr. Jackson of the Prospect Laboratory. He said to me some months ago that if I would give him a plat of the deaths, he could tell very correctly whether the water supply had anything to do with it, for the poorest water in our lake cities is in the spring. That certainly is the fact in Cleveland. It is in the spring that the freshets wash out the Cuyahoga River. That is the time of storms. We have some in the late fall, but most of them occur in spring. I went home and platted the deaths. I took the period since our new tunnel went into operation, 1904, and I found that while we had three or four deaths a month throughout the year, that in the fall the deaths ran up to ten or fifteen a month, or seven to ten a month, as the case might be. That came in September and October, running into November to some extent.

Then I platted the deaths from typhoid during the fourteen years before the tunnel was extended to the present point four miles from shore. I then found that the deaths from typhoid were chiefly in the springtime when one might expect it if it had been due to the water supply. That was the time when we used to have one hundred deaths per one hundred thousand, and in the worst years thirty to fifty deaths every year.

We have tests daily except Sundays of our water supply, both chemical and bacteriological. I took those daily tests for the last two years and I have platted the averages for those, and also the turbidity tests which we make there, and I found in this way also that our water supply is altogether better in the fall than it is in the spring. Everything seems to indicate that there are other causes therefore for typhoid. Mr. Jackson thinks that flies are the chief cause in Cleveland and in most of our cities. The milk supply has something to do with it probably and also very likely at times in the fall because people come back from their summer vacations. I am not absolutely positive of all the details, as I have not thought to inquire recently, but some months ago Dr. Frederick, our health officer, told me this story, something which I think occurred within a year or two. He said he had found eight or ten cases of typhoid sickness anyway which he traced to a milk dealer. He went out to the milk dealer's home and found that there had been no typohid fever there for a long time, apparently for years, in that neighborhood. He was at the place for a while, and he found this situation, which seems to me very novel, I did not suppose it could have existed. He said that some years before there had been typhoid in that family, and they had a well which was very near the water-closet. Immediately after that case of typhoid in that family they had quit using that well and had drawn water from some other place. But a year ago during a very dry spell, their other sources of supply gave out and they began going back to this well, not so much for drinking, but for washing milk cans, and they found that those typhoid germs had existed all that time in that well. I doubt if that could be the case, and I want to ask if anyone has any knowledge of typhoid germs living that way? I had supposed that they never lived but a few weeks. Dr. Frederick may have been wrong in his opinion on that subject. What say you, Mr. Smith?

Prof. E. G. Smith: Typhoid germs do not enter a resistant condition at all. They do not undergo any change by which they can resist hostile conditions, such as temperature, and I do not think there is much evidence of their lasting for any length of time.

A Member: Is it not much easier to believe that the germs persist in the intestines than that they persist in a well?

Prof. E. G. Smith: They perist for years in persons who have had the disease. That has been demonstrated in the case of a servant girl who carried the disease from family to family. They found that she carried the seeds of the disease about with her especially in the urine more than in the body.

Mr. E. W. Bemis: I have heard of that claim. I think the diagram I will have in my report will interest many of you in the points we have made.

Mr. A. H. Wehr: It may interest some of you to know that the medical fraternity in the state of Maryland, if not all over the country, is becoming daily more enlightened as to the possible sources of typhoid contamination. About a year ago it was my pleasure to attend a meeting of the medical faculty of Maryland. Professor Caird happened to be in Baltimore at the time and went with me. He can perhaps more intelligently tell you what occurred at that meeting than I can. I recall that a paper was presented by Dr. William H. Welch in which considerable stress was placed upon the importance of keeping in mind the likelihood of contamination through contact He paid particular attention to a chronic case known as "Typhoid Mary." This "Typhoid Mary" is still in quarantine on North Brother Island, New York. As I remember the Doctor's paper it stated that "Typhoid Mary" had never been taken down with typhoid fever, being apparently absolutely immune, and yet she was and is a chronic carrier of the disease. Doctor Welch pointed out that great danger of contamination rests in contact prior to the patient being taken down, and again during the convalescent stage. While the patient is actually in bed, precautions are taken; but before the disease reaches that point when it is necessary for the patient to go to bed, the danger from contamination through contact is just as great as it is while the patient is in bed. After the patient is again up and about the typhoid bacillus will continue to exist in that patient for a long period, extending, in some cases over as much as two years, during all of which time danger of contamination through contact exists. We in Maryland are in thorough unison with the State Board of Health in the matter of water purification, the State Board being conversant with all our plans, and it is due to this coöperation that we are progressing so well in our work.

The medical fraternity has largely come to the conclusion that in typhoid fever the water supply is not the first cause that must be looked to; but the investigation must be extended to other causes such as milk, flies, and raw vegetables, as well as cases arising through contact with other cases at some period of or before the disease. The matter of raw vegetables has been a very serious question in a certain portion of our territory. There are a great many truck farms in the lower part of Baltimore county, where vegetables are grown which are fertilized with night soil, and this practice has grown to such an extent that the State Board of Health has stopped the use of night soil for that purpose. This action of our Health Board will, I think, have a very important bearing upon, if not the direct cause of improvement in the typhoid fever conditions in the portion of our territory which is subject to the effect and result of the practice stated.

Prof. E. G. Smith: I think along the line of the fact of the existence of typhoid germs in a virulent form, the work of the board of water supply in connection with the sanitation of the Croton basin is very interesting in the construction of the aqueduct from the reservoir of New York and the tunnel across the Croton reservoir. As a precautionary measure a special sanitary station has been established for the purpose of policing the construction camps. This sanitary department is not only provided with a sewage disposal plant for the removal of human wastes in the most careful manner, but every workman in the camps employed by the contractor is being subjected to tests to find out whether the individual is a typhoid character. If found to be such the workman is eliminated from the camp. I think that is a progressive step that has not been adopted elsewhere, and it is rather novel.

I might speak of some work which I did in Baltimore in regard to the water supply there. I had occasion to look up the effect of general sanitary conditions on the typhoid fever death rate, and found that the towns and cities of Europe which were provided with proper sewers, although nothing had been done to improve the water supply, showed a marked decrease in the typhoid fever death rate. I did this in connection with an agitation for filtration of the water supply of Baltimore, which I found at that time was premature and ill-advised.

When I made that investigation I had another theory entirely different from the present theory which Mr. Bemis has brought out tonight. I attributed it more to the reduction of the vital resistance of the human system as a result of improper sanitary conditions. I have recently come in contact with Doctor Jackson and his fly theory which he has brought out in a little pamphlet which he published under the auspices of the Merchants Association of New York, and which he entitled "The House-fly at the Bar."

One occurence which Doctor Jackson presented in that paper is related in the souvenir edition of *Fire and Water Engineering*, in an article which I wrote for Mr. Shepperd. The Doctor proves very conclusively to my mind that the effect of sewers in the importance of general sanitary conditions is largely due to the reduction of the possibility of contamination being carried by flies and other insects. This accounts very largely, in my judgment, for the fact of this marked reduction in disease following the introduction of proper sanitary methods, and it is peculiarly interesting in relation to this water supply question which Mr. Bemis and Professor Smith have brought up, to the effect that the water supply is very frequently blamed for some thing for which it is not responsible.

Take Baltimore for example, a town which has a reasonably good water supply, but very poor sanitary conditions. You have similar conditions in New York and Boston, and you find that there is a direct increase as the fly season approaches, and that the typhoid fever death rate is at its maximum at the very season when the flies are at their maximum. It simply indicates what might be called the residual typhoid fever death rate. Go to towns having a poor water supply and poor sanitary conditions, among which towns Cincinnati might have been classed up to about the present time, and you find that there is an intimate relation between the summer season and the rise of typhoid fever. I think that is a point that is very interesting to all of the water works fraternity, and that it eliminates a great deal of our alleged responsibility, although it should not make us careless in protecting our water supplies from unnecessary contamination.

Prof. J. M. Caird: In regard to Mr. Wehr's mentioning the meeting in Baltimore that we attended, Doctor Rosenau of Washington gave the results of his investigation in regard to the typhoid fever outbreak at Washington. Of course it is well-known that for many years the Washington water supply has been accused of being the cause of typhoid fever. After the filtration plant was installed and in operation the typhoid rate was higher than before, and they made a very thorough investigation which seems to have eliminated the question of the quality of the water. When a typhoid fever outbreak occurs in a city the doctors are all crying and sympathizing with their patients; but did you ever observe that those same doctors do not report their cases of typhoid fever to the health department as soon as they have made a diagnosis? No, they let it run along, and that is one reason why the typhoid fever gets such a start before any investigations are begun, and if it is due to the water the chances are that any pollution which has been in the water has already come and gone, and it is impossible to find it. I know of one city where through the health department a private water company offers $1 for every case of typhoid fever reported by the doctors. I do not approve of that. They found out after a while that they were getting quite a number of cases of typhoid fever reported, and they finally woke up to the fact that they had better have the health officer look after such matters personally, and they do not have quite so many cases as they had heretofore, but they are still paying the doctor. Coming down to the subject of typhoid fever from milk, I had an epidemic brought to my attention which occurred last summer in a city of about thirty-five thousand population. By the way, in that city if a physician does not promptly report a case of typhoid fever he is liable to a very good fine imposed by the health department under a local ordinance. The health department furnishes the physician with addressed postal cards, and all he has to do is to give the location of the patient and immediately mail the card to the health department. Well, they had within two weeks forty cases of typhoid fever, twenty-nine of which were on the route of one milkman. They went to the farm and found that the woman in charge said she had not been feeling very well. They took a sample of her blood and subjected it to the Weidal test and it gave the characteristic reaction of typhoid. So they immediately took out an injunction restraining this farmer from bringing milk into the city. They went to the farm to serve the injunction, and they found two of the farmer's sons sick in bed. They took samples of their blood which again showed a positive reaction. Those cases then ran through the full course. There were twenty-nine cases of typhoid fever on this one milkman's route. Over eleven were traced, but he had been accommodating his dealer friends when they were a little short of milk and in all there were forty cases with four deaths.

It has been a general practice always in looking over the reports of deaths from typhoid fever, when there is a high typhoid death rate, to attribute it to a bad water supply; but I have come to the conclusion that before the water supply is condemned for the typhoid fever death rate that a careful investigation should be had of every case of typhoid fever known to exist.

Certain cities are so located that they have good hospitals, the patients are all rushed from the surrounding places into these hospitals and if they die up goes the typhoid fever death rate and they lay it to the water supply. I think the water works men should insist upon a more thorough investigation before the water supply is condemned.

MR. W. S. CRAMER: We had an epidemic of typhoid fever in Lexington three years ago which was traced directly to the milk supply. I was very much interested in Professor Smith's paper because our cases were all along that same line. We had twelve deaths out of some seventy-five cases. Fortunately for the water company the first five cases were not using city water. They were using cistern water. The cisterns were immediately tested and nothing found there. Then they went right to the milk supply. They were first thrown off the scent quite unintentionally on the part of the dairyman because of the fact that the cows had been moved to a different pasture from that which contained the infected water supply to which the contamination was finally traced. The infected spring was not at first located. The dairyman had two springs on his place, the family not using the one which was afterwards found to be infected. When the spring which was at fault was finally located it was found to be in a horrible condition.

Prof. J. M. Caird: About what was the typhoid fever death rate at Beloit?

Prof. E. G. Smith: Very small. For years we did not have any deaths.

Mr. William Bishop: We have had a little trouble this spring with typhoid fever in our city, and have had two very peculiar cases.

1. A woman sickened with typhoid fever, whose sister had the disease in the same house five years before.

2. A man was stricken about two weeks later with the same disease, and his wife had also had it five years previously. There was no connection between the families.

So far as the water supply was concerned, we could not trace it particularly to that. I think there have been about thirteen cases altogether this year, whereas for the past two years we had no cases of typhoid fever at all. Our water supply is tested daily for Coli bacilli.

Prof. J. M. Caird: You take about two samples for testing everyday?

Mr. William Bishop: Yes; I think so.

MUNICIPAL OWNERSHIP IN EDMONTON

A. MACLEAN

The following outline of a series of municipal enterprises conducted in the city of Edmonton may be of interest to most of the members of the American Waterworks Association. Few of the delegates attending the convention can be much in touch with the principle of municipal ownership and management. The general absence of belief in the adoption of the principle is evidenced by the fact that only a few city councils on the North American continent have had the temerity to indulge in such experiments, and the writer, in placing before the convention this summary of Edmonton's doings, is actuated by the desire to make known to his fellows engaged on civic utilities, some facts seldom met with on this continent. In no way is the paper intended to convey the idea that all cities can operate their own utilities successfully. The great essential of the success of all enterprise—good management—may or may not be present in the attempt of a city to own and operate its own utilities. Where it exists, success will result; where it is absent, failure is sure; and the presence of good management should alone dictate the extent to which the principle should be adopted.

It is generally conceded by all authorities on the development of municipal ownership that the city which starts on the path of collective enterprise usually begins with water. The municipal control and operation of waterworks is the first logical step in a city's growth towards municipal ownership. The fact that water is the first utility which a city seeks to own is due to a number of obvious causes, the foremost of which is the relation of a pure and plenteous water supply with public health and fire protection. It might be unsafe to contend that all cities (or the majority of cities) on this continent own their own water supply, but it is generally the case that cities seek to own that utility before owning others. As a waterworks superintendent I have always believed that the public health and security from fire enjoyed by a community is measured by their ownership of the water supply and the intelligent interest which the community takes in that ownership and operation.

In the city of Edmonton, however, where the writer is at present situated, the council has gone far beyond the initial step of taking over the water supply. Early in its history, the city fathers conceived the idea that anything of the nature of a monopoly could be best administered by the city. The sphere of activity in a city which is usually occupied by the telephone company, the street railway company, the electric light and power company or companies has in this city been occupied as a legitimate ground to expand the functions of municipal government. The conservative minded observer, who believes that private control alone can successfully manage large undertakings, may look with grave misgiving at such a gigantic undertaking in collective enterprise, yet the experience of the city of Edmonton is that the adoption of the principle has been phenomenally successful.

The writer during that portion of his life as a municipal servant in the city of Vancouver had little belief in the success of a municipality to undertake the operation of street railways, telephones, etc. On arrival in this city, however, he was faced with a new set of conditions. Obstacles which he believed existed to make municipal ownership an experiment of some risk he has seen overcome easily. Benefits which he believed could be best realized by a municipality whose enterprises were in the hands of corporate interests he has seen were the lot of the citizens of Edmonton to a degree and in a measure never before met with in his experience in other cities. Naturally, he has been forced to revise his ideas regarding municipal ownership; he has had to reform his conclusions in the light of an array of evidence hitherto not in his possession. If it were not for the length to which a discussion of the principles underlying successful municipal management might be carried and the inability of the writer to do such an important subject justice, it would be his endeavor to deal with the entire subject. Failing such a discussion, however, he would like to summarize some of the benefits of the adoption of the principle in Edmonton, and emphasize what appears to him to be the greatest factors of its success.

The city government here consists of a mayor and council, elected by the people; a board of three commissioners, one of whom, the chairman, is the mayor. The commissioners are appointed by the council, one being known as finance commissioner and the other as public works commissioner. In mentioning the composition of Edmonton's civic government, it is the writer's opinion that the form of government has no direct relation to the success or non-success of the principle of municipal ownership. Given a community of average intelligence, possessed of a normally live interest in its own affairs—a community holding its elected aldermen responsible for the success of its administration—it matters little whether the commissioner system or the committee system be the method of administering the business. Responsibility for the success of the city's enterprise is of far more moment; and the community which retains the services of its best aldermen and sees that their administration is always at the high-water mark of efficiency, will secure results independent of what form the government of the city takes.

In the matter of its selection of councillors, the city of Edmonton has been singularly fortunate. Men of sound business experience have willingly given their services, and the record of the past five or six years of municipal enterprise has produced results which are a credit to all concerned.

It may seem strange to many that such a statement should be made, but the writer is convinced that the councils of the city of Edmonton have carried through work, embarked on projects, financed undertakings, with a degree of success impossible to private enterprise. All this has been accomplished, too, without any monetary interest accruing to the directors, who, sitting in their capacity as aldermen, have worked more efficiently than the directorate of a trust, with the largest possible dividends in sight, would have done. In this connection, he would like to mention a few striking differences between private enterprise and municipal enterprise.

The first difference most noticeable is, the ease with which a city with an assured future can borrow money in the world's markets. When the markets of the world are closed to the best class of security held by corporate interests, the well-governed city can obtain money for its undertakings with ease. It can at all times secure more and cheaper money for its ventures than private enterprise can secure for the same kind of ventures. And this is one of the first and greatest advantages which municipal ownership and operation has over private ownership. It may be that the people of Edmonton have a different viewpoint from that of the people of other cities. The writer knows they possess a viewpoint which was not his before he lived here, but it cannot be denied that the determination which they have evinced to control their own franchises has resulted in a success creditable to their council and themselves.

Another difference between municipal and private enterprise is the fact that the citizen who uses the city's water is aware that its rates coincide exactly to the cost of production of water. If his rates are high, then he seeks to discover the cause, and the result is usually that he does discover it, and the inefficiency or lack of economy is remedied. So it is throughout the whole field of municipal management. The fares of the street railway cheapen in proportion to its success. The rates of the electric light, power and telephone are reduced as the increase in the number of users of these utilities makes economy possible. This is not a mere theoretical statement of the effects of municipal ownership: *it is the actual experience of the citizens of Edmonton.* Some may imagine from this that an ideal condition of life must exist in our Albertan capital, so the writer hastens to assure them that we are not yet a Utopia, but bear all the evidence of being one in the making.

The writer now comes to what he believes to be the greatest controlling factor in the success of municipal management in Edmonton—the fact that the heads of departments have been given complete control of their respective spheres, with a tacit understanding that they have been placed there to make good or get out. Not merely is the mechanical operation of each department completely under the control of the superintendent, but he also is responsible for all the financial details involved in its operation, both of revenue and expenditure. This entirely precludes the interference from which expert city officials sometimes suffer, and leaves each superintendent to pursue the even tenor of his way in peace. The value of such a course, viewed from the point of efficiency, cannot be overestimated. It is hardly to be wondered at, that Edmonton should forge ahead on its progressive course, and that with a street railway system which would do credit to a city twice its size and fifty times its age; a telephone system of the latest Strowger automatic electric type; a power and light system growing fast, but scarcely fast enough to accommodate users on account of its exceedingly low rates; an extensive waterworks system gradually being evolved and expanded to meet the demands made upon it by its growing population; Alberta's capital should lead the way to a condition of municipal life in which all the cities of North America should control their own franchises and utilities and dispense with all the scandal and suspicion of graft, which connects itself with their sale.

DISCUSSION

MR. E. W. BEMIS: What is the population of that city?

MR. J. M. DIVEN: It was estimated at ten thousand in 1906.

MR. H. F. DUNHAM: That was a very fine introduction to a paper. Just when we are all interested in the subject and anxious to know what was actually accomplished, the text ends abruptly.

If the author will please return next year, with plans and descriptions defining his work he will have the closest attention and further thanks from the members.

MR. EDWARD BEMIS: I do not think I will attempt to refer to Edmonton, as we know so little about it; but I hold in my hand the report of the Milwaukee water department for the year just closed, which perhaps illustrates very well certain reasons why there has been so much of a movement toward municipal ownership of water works. The city of Milwaukee has apparently paid for all its plant in two ways. It has been mostly by earnings, but in part the street mains have been paid for by assessments on the abutting land. Only the small mains, the mains that are tapped, are paid for that way—a rather unusual custom, yet it prevails in some places. The mains at the street intersections seem to be paid for by the general revenues of the department. The department in spite of the fact that it has paid for its land, its buildings, its machinery and its larger and some of its smaller mains, out of earnings, has practically no debt. The debt is less than $300,000, on a property the physical value of which, I believe, is $7,000,000 or $8,000,000. They appear to have had very low rates, six cents per thousand gallons i. e., forty-five cents per thousand cubic feet for all consumers.

One might assume for the sake of argument, that a private company would be more economical in administration; but let us see how much they could save in operating costs compared with what the city is able to save in interest and dividends.

The maintenance expenses last year in Milwaukee, which included the operation and everything except new construction, all the expenses, were $231,000, using round numbers. In addition to that they paid for construction out of the revenues.

Now that maintenance ill be the one item I suppose in which private management might excel. I do not say that it would. I do not think in all places it does; but for the sake of argument we will assume that if they could do that business twenty per cent cheaper they would save nearly $50,000 in operating expenses under this supposition which I make without any intimation that such would be the case in Milwaukee. I am not reflecting upon the Milwaukee water department, but I merely want to concede this for the sake of argument and would make the same concession for argument with regard to the water department in any other city. Part of that difference would doubtless be due to the lower wages for longer hours of the common laborer. Part of it might be due to making the men do their work more rapidly or more effciently; this assumed twenty per cent saving could not apply equally to all the expenses, but on labor and salaries only, for coal I think is usually bought as cheaply by municipalities as by private companies, and the same is true of most other supplies. If they were saving twenty per cent in all the expenses, therefore, they must save over thirty per cent in the wages and salaries, so it is an extravagant assumption to talk about twenty per cent saving. I do not think it would exist, I am only assuming it.

On the other hand, what does the city get? Assuming the plant is worth $7,000,000 or $8,000,000, the city would have paid only four or five per cent interest on this, or from $280,000 to $400,000 a year. Milwaukee being a large city would probably not have paid over $300,000 interest. Now if that had been in the case of a private company there would still be a capital account of $8,000,000 on which interest would have to be paid, interest probably of at least seven per cent; and that would be over $500,000 per year.

In addition to that a private plant would probably have capitalized the good will or going value or franchise value, or something else, to the extent of at least twenty-five per cent of the physical value. The value of the pavements put over the mains after they were laid at the city's expense, not at the expense of the company, would have been included. They would capitalize that because that would be a re-duplication of the value, or reproduction of the value, and that would be claimed by the company, perhaps would be conceded in some states by the courts—in some states not. If it were conceded it would probably bring up the total capitalization to at least $10,000,000. Seven per cent on that would be $700,000 and the difference between the interest that the city would pay and the profits of a private company would then be between $300,000 and $400,000. We then have Milwaukee saving over $300,000 in interest charges, and losing at the most on our assumption $50,000 in operating expenses, or a net gain of over $250,000 a year.

Probably a private company would have charged much more on the whole. It might have charged a little less to large consumers, and much more to small consumers. The rates here are abnormally low to small consumers. Probably the total rates would have been greater, and they would have been paid out in dividends and not in reducing the capital account.

Milwaukee by virtue of having municipal ownership has paid for the entire plant out of her earnings without having as high rates as she would have had, probably, under a private company. In consequence now she has no interest to pay. The interest rates last year were only a little over $6000. I believe this year interest will disappear entirely, or almost so.

They are improving their plant entirely out of their earnings. That is more than the depreciation charges will amount to. The earnings of the department the last few years that have been turned back in cash into the city treasury, amounting to many hundreds of thousands of dollars, are already doubtless equivalent to the cost of the pipe that was laid at the expense of the abutting land owners.

I have not discussed depreciation here, but the charge for that will apply equally to private and public plants. Municipal plants generally, as we know, do not set aside a direct sum and call it depreciation, as they should; but they usually accomplish the same thing by putting the earnings into construction. It may not be a scientific manner of bookkeeping but from the standpoint of indebtedness and solvency it amounts to the same thing.

I do not say, of course, that all plants would be as successful as the Milwaukee plant; but I think that this is an astonishing or rather an extreme illustration of the way in which many muncipalities get ahead with the water department, and explains why municipal operation is so popular.

I want to say one word before I close, on the question of the future acquisition of such plants. I was unfortunately absent from the discussion yesterday afternoon on going value, but I think if going value is to be recognized by the courts in appraisals after franchises have expired a concerted move must be made. The supreme court of the United States did not recognize it in the New York Consolidated Gas case as a basis of earnings; although some lower courts appear to have done so. If you want to lease your land for a building you can provide that whoever bids for that land shall put up the kind of building you specify, and at the end of the lease the building shall become the property of the land owner. You may not think that is a good thing to do in a public department, but we see it done all the time in private work and nobody criticises it. It is being done every month of the year in all the larger cities. It is perfectly just if it is in the specifications. Parties do not have to bid if they do not wish. Therefore, there is no injustice done to the owner. I do not think it is good policy, however, in the case of any public utility to provide that at the end of the franchise period the plant shall go to the city free of charge, because the temptation would be to allow it to run down the latter part of the period of the grant, as seems to have occurred with the Chicago street railway three or four years ago. But I do think that we can easily provide in future franchises that bids shall be subject to the condition that at the end of the grant the city shall have the right to purchase on payment of the physical value without regard to going value, or franchise, or good will, or anything except the present physical or structural value. In this we should of course take into account the condition and depreciation of the property. There would be no injustice in that if it was in the franchise; therefore, if municipalities wish to guard in the future against the possibility of a large payment, they can easily do it in that way.

As much as I have written in favor of municipal ownership, I do not urge that all cities should go into it immediately. I think that in reality the best scheme is to have a number of both types of plants, municipal and private, side by side, under a strict system of state accounting, publicity of accounts and examinations and all that. Thus you could have the most thorough and rigid comparison of results, and the formation of a wise and intelligent public opinion. I believe that the right policy for many cities is to have the right to own and operate not only water but electric light for public and commercial uses, street railways, etc. This right would be a magnificent safeguard. It would result, as it has in Great Britain, in private companies being more careful to satisfy the public. And that does not imply that many of our private companies in this country are not now doing it, because I believe they are. I believe that many of the private companies represented in this Association are giving magnificent service to the country. We recognize the trend of public opinion toward municipal management. I am only speaking as to how it can come about in the wisest manner.

Mr. J. M. Diven: I do not know where Mr. Bemis has had his experience with privately-owned water works, but it must have been in a much richer field than most of us have had experience in. His comparison of possible results for private ownership in Milwaukee is entirely one-sided. I think that a water company would not expect to or be allowed to charge as part of its capital the cost of laying mains which were paid for by the owner of the property in front of which they were laid. Moreover, if such an arrangement could be made by a water company, I believe that their rates would be very much less.

Mr. Bemis sees fit also to discuss going value with municipal ownership. Now is it not a fact that in the cost of the Milwaukee works, going value is taken into account? There must have been a time during the original construction of the works when there was no income to meet expenses, and also some years when the income did not meet expenses and interest. However, this has been charged in the construction account or the deficiency was paid by the taxpayer direct, which amounts to the same thing. He speaks of the rates as being very low, at the same time says that a large part of the construction has been paid from earnings. How can rates be low when they are high enough to provide not only for operating expenses, interest and other fixed charges, but also to pay the cost of construction? Again, were these rates as low at the time that the large sums were being appropriated from the earnings for construction? He speaks in a general and vague way of amounts being turned into the general fund by the water department, but does not say how much has been turned in in this way, or in fact, whether anything has been. If it has, in the speaker's opinion, it is a wrong proceeding, for it is making the water-taker pay for benefits shared alike by those who do and do not take water; and if the water department has a revenue more than sufficient for its own needs, it would surely be a much more fair proposition to reduce the rates. In estimating the interest charge that would have to be met by rates if the Milwaukee Works were owned by a private company, he uses seven per cent. Now, I do not know of a water works company even in small towns, that are paying as high a rate of interest as that. Nor is any such amount paid in dividends. A private company owning works in a city of the size of Milwaukee, would be able to borrow money at not to exceed 4½ per cent, if the city is, as is the case with Milwaukee, a prosperous, growing city, where the company could show good business. I think if Mr. Bemis will examine the records he will find that many water companies are borrowing money on the 4½ per cent basis, and I doubt if he will find many, if any at all, that are paying 7 per cent dividends.

MR. H. F. DUNHAM (by letter): In making such comparisons great fairness ought if possible to be introduced. If a private company had been in control of the Milwaukee water supply throughout its past history it would certainly be reasonable to take into account the yearly sums that the said company paid into the treasury of the city for taxes. Do Mr. Bemis' tables of figures carry an estimate for this item?

Is it quite fair to select a particularly "Bright Spot" for comparison? In another lake city a distinguished army officer once presented to a society of engineers a paper on "The Harbor of Refuse." With true regard to detail he described the rapid filling up of the harbor, the percolation through the breakwater, the advance to the water supply intake, the course through the tunnel into the distribution system and finally to "the stomachs of the citizens *whence it came*." That was back in the eighties when the true significance of water pollution with respect to the spread of disease was beginning to be well understood.

Recently typhoid fever statistics from the same city were presented to this Association. Back of these figures are others that cover the long period of suffering from that disease.

Suppose that city's water supply had been in the hands of a company required under a franchise "to furnish good and wholesome water" during these years. It is not rude or unreasonable to ask the gentleman for his opinion as to the average quality of the water furnished under such assumed conditions when compared with the quality of the water actually furnished during the said period. The inquiry should lead to a little study of the part taken by water companies in this country in perfecting methods of filtration. It might help to show that the speaker's first reference to great fairness in touching upon such questions is timely; that considerations hardly inferior to the rare engineering ability and the cosmic forces which have favored the "Bright Spot" are involved; that these cannot be summarized on the pages of a commercial ledger and finally that statistics are sometimes worth including in a declaration often made about charity.

Mr. E. W. Bemis: It certainly would be necessary for a private company to pay taxes. I do not know that I am sufficiently familiar with matters in Milwaukee to place side by side a comparison, as I have been able to do in Cleveland, between the taxes which the private company would have paid and the value of the service which the city has to provide free, and which the private company would have charged for. In Cleveland I have made a very careful estimate. The free service last year to the city of Cleveland was $328,000. That is estimating hydrants at only thirty dollars; but the taxes would have amounted to less than $225,000; and the value of the rental of the part of the city hall we occupy, and certain free service we get from the city auditor, city attorney, board of public service and a few other city departments, which I believe as fair bookkeeping should be charged to us, would still show a balance in our favor. I have estimated the value of all the free service based on what private companies similarly situated are charging. I thoroughly agree with the point of the last speaker that that item should not be overlooked.

Mr. H. Hymmen: Ten years ago our town took over the plant of the then existing water works company at a valuation of $102,000. Since that time, during the ten years, we have added to the plant, which is now worth $220,444, and we have issued bonds since then amounting to $24,000; deducting what we have paid out on the bonds leaves a balance over and above indebtedness now of $96,820. We have a sliding scale from six cents to thirty cents. The thirty cent rate is entitled to thirty per cent discount. We have a population of about thirteen thousand.

Mr. H. F. Dunham: It should be understood that companies furnish free services in the same relation to the general service as that which is furnished by the municipalities.

Mr. E. W. Bemis: As brought out I believe in my oral discussion, Milwaukee, like Chicago and many other municipal plants, has furnished to the city in free water and in other ways a much greater value than the taxes and other expenses which it has been exempt from, but which would be imposed on a private company.

With respect to typhoid fever, the forthcoming report of the Cleveland Water Department for 1908 will show some interesting facts. Of the eight large private companies in the fifty largest cities, only four, Paterson, Scranton, St. Joseph and San Francisco, were among the twenty-five cities having the lowest typhoid death rate in 1907 and 1908, while one of these, Scranton, was in the lowest half of the fifty cities in 1906. The eight private companies do not average any higher rank than the forty-two public plants in our fifty largest cities in the matter of the typhoid death rate.

Mr. J. W. Alvord: This subject of the municipal ownership vs. private ownership of public utilities probably will have a perennial interest for most of us for another generation to come, and I do not think it will ever be fully settled as long as there is anybody left with health and strength to discuss it. For myself, I might say it lost its interest a good many years ago from the fact that I came to the conclusion that most of the discussion neglected the human element involved in *management*. After some thirty years experience with many city councils as well as many private utility companies, probably over two hundred altogether, I have come to think, whether rightly or wrongly, that I know something of the human nature of the municipal corporation, so to speak. I find that the human nature of the municipal corporation, as a whole, varies about as much as human nature does elsewhere, and that the whole question of who had best administer the public utility, when you come to boil it all down, is simply a question of management, —good management. I find good management in cities; I find good management in private water companies. I find bad management in cities; I find bad management in companies. I find sometimes dense ignorance in some public utilities companies as to financial matters. I also find sometimes dense ignorance in cities as to proper financial ideas.

And this one feature of the human element is so varying, there is such a wide range of the variation that all other arguments pro and con subside into comparative insignificance in comparison with it. The minor advantages and disadvantages ,will continue to be argued over: there is something to be conceded on both sides. There is no doubt but in public utilities owned by the city, the city can borrow money more cheaply on its general credit than water companies can on their limited credit; but there is no doubt also that cities are not obliged to account fully for every debit and credit, and therefore they sometimes deceive themselves as to the financial standing of their utility investment. Aside from those things, which are interesting enough, but which are not to my mind of great importance, cities labor under one disadvantage—a tremendous disadvantage, and that is this, that in most cases the managers of the city go out of office every two years. Just about the time they get some insight into their occupation; just when they have got a fairly competent beginning of knowledge as to what they have got to do, and begin to see how they can run things rightly and properly, they go out. A fresh, brand new man comes in, full of enthusiasm perhaps, well meaning, but wholly inexperienced. Now in going about from place to place and meeting the average city councils in this country, I am pleased to say that I find, in a large majority of cases, patriotic, well-intentioned, earnest and conscientious men are in city councils, men who earnestly want to do something wise for their cities; yet the first thing that they have to learn is that the operation of a municipality in this country is a skilled profession. It is not purely a business; it is a skilled profession only gradually and painfully acquired. The operation of a city's affairs is surrounded by legal checks, by laws, by slow stages, by everything that can retard in the interest of safety and honesty, so that until you have learned all the workings of those special laws and all the intricacies of especial finances, and all the results of those checks, you cannot hope successfully to carry out any public enterprise without delays or reverses. It takes just about two years to learn the job of running a city for an average bright mayor.

Now the result of this, as I have frequently said elsewhere, the result, especially, of this rotation in office is that the losses in our American form of municipal government, the waste, so to speak, would in my opinion keep this country involved in a continuous costly foreign war. I think that is perhaps a mild illustration of what in my opinion is the waste from, I do not like to say ignorant management—because that does not fairly express it, but the waste from our democracy; that is to say, the idea that we must educate up everybody to be a general manager, even be it at frightful loss to ourselves. The officers of all of our city governments are thus being constantly educated, class after class, but just as soon as we get them graduated we are done with them in most cases.

Now that city which does not yield to the democratic idea of rotation in office, but happily finding itself well officered, keeps in those men who have arrived at their graduation honors, as we might say, and holds them in for term after term. These are the cities which in my experience are reducing the municipal waste most successfully.

I know of no places where matters are better managed, better run, where better business judgment is exercised, than in those cities where the mayor or the strong councilman, I do not care where you find him--you nearly always find somewhere the strong, thoughtful common-sense man, whose judgment is respected by his fellow councilmen, and who, you will find, is running things, and when you keep the fingers of that man on the public purse and when you defer to his judgment year after year, whatever the community may be as to its size, its opportunities, or its other features, there you will find the public money better spent, more sensibly spent, and better business management prevailing.

I do not often care to express my mind on these subjects, because these features that deeply impress me I hear little discussed, while other details of the controversy between municipal ownership and private ownership that I consider minor, occupy the minds of those interested to the exclusion of all else.

MR. H. HYMMEN: I would say our water works are not run by the council but by a board of commissioners two of whom are elected every year, the mayor being a member of the board ex-officio. Our present chairman has been in the board ten years, another member nine years. There is very little change in our board.

MR. HARRY ELLSWORTH: Speaking of the danger of too rapid changes in the management of a municipally conducted plant, I will say that our town has been conducting a municipal street lighting plant for twenty-five years, and a water system for ten years. During the twenty-five years there have been two changes, one of which was voluntary. Politics does not enter into it in any way. The water system is maintained entirely from its own revenues.

MR. S. J. ROSAMOND: Professor Bemis made a comparison that I do not think is a comparison. He referred to private contracts between individuals in the leasing of lots for the purpose of erecting thereon improvements and then enjoying the advantages of the improvements, and after the expiration of the term of the lease the improvements finally reverted to the owner. It is true that business transactions of that kind are had in this country and that every lessor of such property is permitted to enjoy the use of it during the period of the contract without any interruption from the owner of the land. He is not subject to the whims of every politician who may take a notion to enact bad legislation. He is given all the rights of peaceful possession under that contract during its life. On the other hand a municipally owned plant has a law-making body behind them ready and willing at all times to pass any legislation for the benefit of the property that they see fit; as for instance, in Milwaukee, as just stated, in the frontage tax which means that the real estate fronting on the streets piped actually paid the cost of the mains in the street. A corporation accepts a franchise from the municipality for a utility and it is forever after during the life of that franchise subject to all good and bad legislation which may be enacted. I know of one state that had bills presented in the legislature making the water companies of the state liable for all losses by fire. Why? A member of that legislature had a property burned, and he proceeded to have himself elected to the next legislature for the sole purpose of passing that bill.

I could name you numerous instances where councilmen have gone into council, and in one instance the mayor, just because he was after the street car company. Now that street car company was said to be one of the best in this country, but he was in that class, he was a politician and he had it in for the company. So I say that is not a fair comparison. The one enjoys the rights under the contract made with the land owner during the life of that contract, and he enjoys the rights peaceably and is not subject to all kinds of legislation; on the other hand the corporation or utility company is subject to all the good and bad legislation that good and bad politicians see fit to enact.

LIABILITY OF WATER COMPANIES FOR FIRE LOSSES

BY CHESTER R. McFARLAND

This is a subject which has at sometime engaged the attention of the water works superintendents of at least twenty-two states, and in some of these states is still a very serious question, and particularly is this so in the state of Florida.

On the twenty-third day of May 1905 there occurred in the city of Tampa a fire which burned a brick building in which there was located on the first floor, two places of business; one a saloon and the other a five and ten-cent store known as the Bee Hive. Over these two stores was located the armory of the local militia. Adjoining this building on the north was a two-story brick building in which there was located on the ground floor two places of business; one was a pawnbroker next to the burned building, and the other a hardware store, and over these stores were warerooms. The fire broke out in the Bee Hive, which was caused by an explosion of a gasolene lighting system, and was communicated from there to the saloon and the armory. The fire department failed to control the fire until after it had destroyed the first building, and damaged the goods of the pawnbroker in the adjoining building. The building in which the fire started was owned by R. Mugge, and he brought suit against the Tampa Water Works Company to recover for the loss of the building and saloon, on the ground that the Water Works Company did not furnish sufficient water to put out the fire. The company demurred to his bill of complaint, and the Circuit Court sustained the demurrer. The plaintiff took an appeal to the Supreme Court of the state, and the Supreme Court reversed the Circuit Court and remanded the case for hearing on its merits. (52 Fla. 372). This case has never come to trial on its merits.

On March 1, 1908, a conflagration occurred in the northeast part of the city, and a large district was burned and nearly one hundred suits were filed against the Water Works Company, aggregating about $1,250,000. Almost all of these suits were filed by the insurance companies who had taken subrogation from the owners; one of these cases coming up for hearing in the Circuit Court, the Water Works Company demurred, and the Court sustained the demurrer. The plaintiff appealed to the Supreme Court. This case is known as the A. C. Woodbury vs. Tampa Water Works Company. When it was heard in the Supreme Court, the Court sustained the Circuit Court on the ground that the plaintiff's property was not located where the fire started, and that it did not appear that the defendant was in any way responsible for the starting of the fire, or it was under a duty to extinguish the fire, or that it did not supply with water, as legally required, the hydrant at or near the plaintiff's property at the time the fire reached the property.

I am not a lawyer, and have had to rely largely on the briefs submitted by the attorneys of the Tampa Water Works Company, to whom I am largely indebted for the references herein contained.

The case of Paducah Lumber Company vs. Paducah Water Company, 89 Ky. 340, was the pioneer case (decided in 1889). In this case the Court held that a Water Works Company which has made a contract with a city to supply hydrants with water is liable to an individual for negligence whereby his property is destroyed by fire, but doubt if the Court would have gone so far had there not been in existence in addition to the city contract, a contract directly between the plaintiff and defendant binding the latter to furnish water to the plaintiff's private hydrants. This seemed to be the opening wedge, and was followed by suits in various states, not only in cases where there was a private contract, but suits based on the city contract only.

It looks as if the Kentucky Court itself had at one time become doubtful about the propriety of the decision in the Paducah case, for, while the later cases in Kentucky have gone the whole length of the dictum in the Paducah case,

Lexington Hydraulic & Mfg. Co. vs. Oots (Ky. 1905), 84 S. W. Rep. 774, 777.

Graves County Water Co. vs. Ligon, 112 Ky. 775, 66 S. W. Rep. 725.

Duncan vs. Owensboro Water Co. (Ky. 1889), 12 S. W. Rep. 557.

yet in one of the more recent ones it is hinted that it would not do to upset the previous ruling, because such a course would disturb (and especially in that case) the operation of contracts entered into after the Paducah case was decided.

Graves County Water Co. vs. Ligon, 66 S. W. Rep. 725, 726 Ky.

The fact that in the Paducah case there existed a direct contract between the plaintiff and defendant binding the latter to furnish water to the plaintiff's private hydrants, undoubtedly had some influence with the Court as pointed out in

Lovejoy vs. Bessemer Water Works Co. (1906), 146 Ala. 374, 7 Ann. Cas. 1068.

Bush vs. Artesian, etc., Water Co. (1895), 4 Idaho 618, 43 Pac. Rep. 69 95 Am. St. Rep. 161.

Mott vs. Cherryvale Water & Mfg. Co. (1892), 48 Kan. 12, 16, 28 Pac. Rep. 989, 30 Am. St. Rep. 267, 15 L. R. A. 375.

Eaton vs. Fairbury Water Works Co. (1893), 37 Neb. 546, 552, 56 N. W. Rep. 201, 40 Am. St. Rep. 510, 21 L. A. R. 653.

Stone vs. Uniontown Water Co. (1895), 4 Pa. Dist. 431.

Boston Safe Deposit & Trust Co. vs. Salem Water Co. (1899), 94 Fed. Rep. 328, per Ricks, D. J.

In other cases the reasoning in the Kentucky Court has been pronounced unsatisfactory for the case having been cited by the council for the defeated plaintiff as the report shows, it was ignored in the Court's opinion.

Fitch vs. Seymoure Water Co. (1894), 139 Ind. 214, 37 N. E. Rep. 982, 47 Am. Rep. 258.

Wilkinson 78 Miss. 389, 28 So. Rep. 877.

Metx vs. Water Works & Electric Co. (1906), 202 Mo. 324, 100 S. W. Rep. 651.

Howsman vs. Trenton Water Co. (1893), 119 Mo. 304, 315, 24 S. W. Rep. 784, 23 L. R. A. 146, 41 Am. St. Rep. 654.

Blunk vs. Dennison Water Supply Co. (1905)- 71 Ohio St. 250, 2 Ann. Cas. 852, 73 N. E. Rep. 210.

Akron Water Works Co. vs. Brownless (1895), 10 Ohio Cir. Ct. Repts. 620, 50 C. D. L.

House vs. Houston Water Works Co. (1895), 88 Tex. 233, 31 S. W. Rep. 179, 28 L. R. A. 532, where Judge Brown noted the fact that no authority was cited in the Kentucky case.

Nicol vs. Huntington Water Co. (1903), 53 W. Va., 348, 44 S. E. Rep. 290.

But the North Carolina Courts followed the Kentucky Courts in the case of

Gorrell vs. Greensboro Water Supply Co., 124 N. Car. 328.

This case was decided in 1899, and is one of the few cases which hold that water companies are liable to an owner of property destroyed by fire in case of failure to supply water and pressure at the time of the fire. The action brought in this case was *ex contractu*, plaintiff suing as a beneficiary of the contract between the city and the company. In this case the Chief Justice and one of the judges of the North Carolina Court dissented in the case. The decision rests chiefly upon the authority of the Paducah Lumber Co. vs. Paducah Water Co.,

89 Ky. 340.

The Gorrell case has been followed in

Fisher vs. Greensboro Water Supply Co., 128 N. Car. 375, 38 S. E. Rep. 912, where plaintiff recovered in an action of tort.

Jones vs. Durham Water Co., 135 N. Car. 553, 47 S. E. Rep. 615, 138 N. Car, 383, 50 S. E. Rep. 383,

where it seems the action was ex contractu.

The conculsion in the Gorrell case was pronounced unsound in

Ukiah vs. Ukiah Water & Imp. Co., (1904), 142 Cal. 173, 179, 75 Pac. Rep. 733, 100 Am. St. Rep. 107, 64 L. A. R. 231.

Nichol vs. Huntington Water Co. (1903), 53 W. Va. 348, 44 S. E. Rep. 290.

Lovejoy vs. Bessemer Water Works Co. (1906), 146 Ala. 374, 9 Ann. Cas. 1068.

The decision in the Gorrell case was rested upon the principle, stated by the Court in general terms, that one not a party or privy to a contract, but who is the beneficiary thereof, is entitled to maintain an action for its breach, and many cases are cited which are assumed to sustain the general proposition, which was stated without qualification. It is not true, however, that the principle can be maintained to the full extent and in the unqualified terms stated by the Supreme Court of North Carolina.

This decision was followed by the Florida Supreme Court in the case of

Mugge vs. Tampa Water Works Co., 52 Fla. 371.

After quoting extensively from Judge Clark's opinion in Gorrell vs. Greensboro Water Supply Co., 124 N. Car. 328 and from Mr. Justice Brewer's opinion in Guardian Trust and Deposit Co. vs. Fisher, 200 U. S. 57, the Court says:

> It seems to us that the views expressed by Justice Brewer and Justice Clark of North Carolina are the most logical and reasonable and most nearly satisfy the sense of justice and right.

It appears that the decision is based upon the ground that the defendant assumed a "public duty of furnishing water for extinguishing fires according to the terms of its contract," and for negligence in discharge of that duty is liable in an action of tort. (52 Fla. at p. 388).

The Court also quotes with approval from the opinion of Judge Thompson in

Lampert vs. Laclede Gas Light Co., 14 Mo. App. 376.

But it appears that Judge Thompson's views have not found favor with the Supreme Court of Missouri.

See Metz vs. Water Works & Electric Light Co. (1906), 202 Mo. 324, 100 S. W. Rep. 651.

Howsman vs. Trenton Water Co. (1893), 119 Mo. 304, 309, 24 S. W. Rep. 784, 23 L. A. R. 146, 41 Am. St. Rep. 654.

The three states heretofore mentioned, that is, Kentucky, North Carolina and Florida, seem to be the only ones that have gone so far as to hold water companies liable to individuals and taxpayers under a contract made with the city for the purpose of furnishing water for fire protection.

As a matter of public policy it would seem that these Courts have erred. Corporations organized for the purpose of supplying water to cities and towns must necessarily perform the service at a reasonable rate, and if water companies are to become insurers of property the rate of returns must be such that no community would tolerate them for a moment, and even if the city would consent to such a remuneration for hydrant rental as to enable the water company, under ordinary circumstances, to protect itself against losses, yet, a conflagration might at any time occur of such magnitude as to bankrupt the company, and thereby disable it so far that it would be unable to protect the very citizens who had been taxed for such an emergency.

If water companies are to be held liable for fire losses then, they must necessarily provide a large reserve fund from year to year to meet any and all emergencies; in other words they become insurers against loss due to any lack of pressure or supply in case of fire. The water company would be placed in a rather peculiar position. The water is to be furnished to the Fire Department of the city, and they are to apply the water, not the water works company, and who can say that the water was not supplied in proper quantity and with proper pressure and that the failure to put out the fire was not due to some neglect or failure on the part of the fire companies. This being the case the services rendered must necessarily be burdened with much unreasonable expense due to a multitude of suits, many of which would have no real and just claim. If the building was destroyed and it was a well established fact that the water company was liable either by lack of supply or pressure, it would be most natural for the fire company to say that the fault was the water company's otherwise the fire would have been put out; and if the fire companies were allowed to use this as a shield, it would result in the destruction of the efficiency of the companies. Nothing that I can say so clearly expresses the full meaning of the liability of the water company as the language of Judge Provosty of the Supreme Court of Louisiana in the case of

Allen & Curry Mfg. Co. vs. Shreveport Water Works Co. (1905), 113 La. 1091, 1109, 37 So. Rep. 980, 2 Ann. Cas. 471.

> Perhaps if the city found a contractor so benevolent or simple as to be willing to assume such a liability without exacting additional pay for so doing, it might be our duty to take advantage of the situation and impose such a liability; but where would we find a contractor of that type? It goes without saying that no contractor would expose himself to a law suit in the wake of every fire, without exacting pay for so doing, and the pay would have to be very heavy, for the experience of every day teaches that negligence of employees cannot be entirely guarded against, and at any moment under such a liability, heavy damages might have to be paid, in fact a general conflagration resulting from negligence of an empolyee might utterly bankrupt the contractor. It is entirely improbable that the city of Shreveport would have been willing to impose so heavy a burden upon her treasury.

This was the language of a court reversing itself in the case of Planters' Oil Mill vs. Monroe Water Works & Light Co.(1900), 52 La. Ann. 1243, 27 So. Rep. 684, wherein the Court had held a water company liable. Having considered the jurisdictions which have held adversely to the water companies, to wit:

Kentucky—Paducah Lumber Co. vs. Paducah Water Co., 89 Ky. 340 (1889).

North Carolina—Gorrell vs. Greensboro Water Co., 124 N. Car. 328 (1899).

Florida—Mugge vs. Tampa Water Works Co., 52 Fla. 371, (1906).

The striking feature is that in twenty other jurisdictions the Court has held for the defendant as a matter of law. These jurisdictions include the following:

Connecticut—Nickerson vs. Bridgeport Hydraulic Co., 46 Conn. 24 (1878), Opinion by Park, C. J.

Tennessee—Foster vs. Lookout Water Co., 3 L. E. A. 42 Tenn. (1879), Opinion by Cooper, J.

Nevada—Ferris vs. Carson Water Co., 16 Nev. 44 (1881), Opinion by Belknap, J.

Pennsylvania—Beck vs. Kittaning Water Co., 11 Alt. 300 (1887), Stone vs. Uniontown Water Co., 4 Pa. Dist. Repts. 431 (1895).

Thompson vs. Springfield Water Co., 215 Pa. St. 275, 7 Ann. Cas. 473, 64 Alt. Rep. 210, 1905.

Georgia—Fowler vs. Athens City Water Works 83, Ga. 219, 9 S. E. R. 673 (1889), Opinion by Bleckley, J. C.

Iowa—Davis vs. Clinton Water Works Co., 54 Iowa (1890), Opinion by Beck, J.

Becker vs. Keokuk Water Works, 79 Iowa 419 (1890), Opinion by Robinson, I.

Wisconsin—Britton vs. Green Bay Water Works, 81 Wis. 48 (1892), Opinion by Ortoro, J.

Kansas—Mott vs Cherryville Water Co., 48 Kan. 12, 28 Pac. 989 (1892), Opinion by Horton, C. J.

West Virginia—Nicol vs. Huntington Water Co., 53 West Va. 348, 44 S. E. R. 290 (1903), Opinion by Paffenbarger, J.

Nebraska—Eaton vs. Fairbury Water Works Co., 37 Neb. 546 (1893), Opinion by Ryan, J.

Missouri—Howsmon vs. Trenton Water Co., 119 Mo. 304 (1993), Opinion by Braco, J.

Metz vs. Water Works & Electric Light Co., 202 Mo. 324, 100 S. W. Rep. 210 (1906).

New York—Wainright vs. Queens County Water Co., 78 Hun. 146, 28 N. Y. Supp. 987.

N. Y. Sup. Ct. (1894), Opinion by Brown, P. J.

Indiana—Fitch vs. Seymoure Water Co., 139 Ind. 214, 37 N. E. Rep. 982 (1894), Opinion by Howard, J.

Texas—House vs. Houston Water Works Co., 88 Tex. 233, 28 L. A. R. 532 (1895), Opinion by Brown, J.

Idaho—Bush vs. Artesian Hot & Cold Water Co., 4 Idaho 618, 43 Pac. 69 (1895), Opinion by Houston, J.

Ohio—Akron Water Works Co. vs. Brownless, 10 Ohio Cir. Ct. Repts. 620 (1895), Opinion by Caldwell, J.

Blunk vs. Dennison Water Supply Co., 73 N. E. R. 210 (1905).

Mississippi—Wilkenson vs. Light, Heat and Water Co., 78 Miss., 389, 28 So. 877 (1900), Opinion by Brother, S. J.

California—Town of Ukiak City vs. Ukiah Water & Improvement Co., 75 Pac. 773 (1904), Opinion by Henshaw, J.

Louisiana—Allen & Curry Mfg. Co. vs. Shreveport Water Works Co., 113 La. 1091, 1114, 37 So. Rep. 980 (1905), Opinion by Provosty, I.

Considering the array of decisions against the liability of water companies it almost seems useless to consider the matter further. But the property owner who is burned out feels that someone is at fault, particularly if he failed to carry any insurance, and is ready to assert that the water company made a contract to furnish water to extinguish fires on his property. This propably seems to him a reasonable interpretation of the city contract. Let us see if this is a proper view of the question.

In the first place the city provides a fire department with supplies, including horses, engines, hose, etc., and also a supply of water. The relation of the individual tax payer to the company that agrees to suppy water is no different from what it is to the person that sells the engine or hose to the city. The power of the city to contract in all cases is the same and derived from the statute. But if from the bursting of a defective hose or the breaking down of a defective engine, the extinguishment of a fire was made impossible, the owner of the destroyed property would have no right of action against the vendor, only the city would have a right of action for the value of the defective hose or engine.

I have heretofore only considered this subject as to the liability of the company under the contract with the city. But there is another feature of this subject that is of more interest to the management of water companies, and that is the making of private contracts for so-called fire protection. The last two words should be stricken from the vocabulary of every manager of a private water company, and no contract made with individuals or corporations for water should contain these words.

There has also been and is now a demand for connections for sprinkler systems. The applicant will tell you that as the company has a contract with the city to furnish water for extinguishing fires, that by providing water for a sprinkler system the company may be saved the expense of furnishing water in case of a large fire. If you ask him to sign a release of liability of the water company he will probably decline for personal reasons or because the insurance companies will decline to accept the risk unless they can have a chance to make the water company pay the loss in case of fire. The result is that the applicant for the connection feels aggrieved at somebody, and the usual thing is to take his satisfaction out on the water company by saying that it is to blame that he cannot save hundreds of dollars each year, but fails to state that the real reason was that the water company refused to become a co-insurer of his premises without consideration. Therefore, all contracts for water for hose connection to be used in case of fire, or connections for sprinkler systems should be carefully considered, and should contain the proper provisions as to liability. And I might suggest that a committee be appointed to consider and report a proper form for such a contract.

DISCUSSION

Mr. C. A. Hague: Mr. President and Gentlemen: I would like, to add a little testimony to this paper that might perhaps be of some interest. From what I have seen in connection with such matters, the courts are very slow in holding water companies responsible for fire losses. I will cite two cases, one in which the evidence was shown by the recording gauge that the water company had promptly raised its fire pressure and had maintained it during the time of the fire. This fire was a cotton seed oil mill situated at the end of quite a long six inch main which was connected with sprinklers, but the sprinklers failed to suppress the fire at the start. It was a very dangerous fire, because the inside of the mill was covered with cotton lint, and a fire breaking out in such material spreads almost like a flash of powder. The fire gained such headway that the supports of the sprinklers gave way, and they fell, breaking off the supply pipes, and there was no way of shutting off the valves except very close to the building where, on account of the intense heat the openings could not be closed. The great outflow of water from the broken sprinkler feeders bled the main so that when the fire department got there and attached hose to the hydrants there was very little pressure, not sufficient to do business. By the time the firemen made up their minds to send for the reserve apparatus, consisting of two steamers and the steamers had gotten there and were ready to work, the cotton oil mill was destroyed. This was at Monroe, Louisiana.

The insurance companies paid a loss of about $48,000, and then brought suit against the water company to recover. The case came up in the United States circuit court before a judge and the decision after a long trial and the production of a great deal of testimony and evidence, was in favor of the water company.

In another case, at Des Moines, Iowa, some years ago there was some contention among the firemen which resulted in bad service, and the council threatened to annul the contract with the water company; but the recording gauge indicated that from the time of the alarm and for a long time thereafter the fire pressure had been maintained in the pumping station.

I also remember another case where the evidence brought out the fact that in a contention among the rival fire companies little packages of stone and gravel had been dropped by friends of one company into the hose so that the other company would not get the first stream. The result was that this rubbish came up into the nozzles, and before anyone could finally get the trouble located and get it remedied the fire had gained a great deal of headway; but as in both the other cases the recording gauge showed that the water works had maintained its fire pressure.

Mr. S. J. Rosamond: I would like to cite one case that came under my notice which I know will be of interest to all those who have this question to meet. I refer to a case in the United States Court for the Eastern District of Arkansas, tried at Pine Bluff, wherein the city sought to have a franchise annulled and a receiver appointed, or both, just after a very large conflagration. Judge Bradford in that court only heard two witnesses, they were the mayor and chief of the fire department—and it seemed that the chief of the fire department's evidence closed the case so far as the court was concerned. After the judge had heard the chief make the statement that one line of hose was 1050 feet and another line 1200 feet, and they failed to get sufficient water to extinguish the fire, he dismissed the attorneys on both sides with instructions that the city officials and the company get together and see if they could reach an agreement as to what should be done to improve the plant, and report to him at two o'clock. He said that he would not annul the franchise and that he would not appoint a receiver, but that he would see that both parties to the controversy did their duty, that the city placed hydrants enough to reach all the risks, or locate them, and that the company put them in and put in mains sufficient to supply them with water.

No further evidence was taken, but they failed to get together. The officials discussed the matter and then they decided that the city officials wanted the case to go on. They went into court and stated that to the Court, and the Court immediately appointed a hydraulic engineer to see that the city did its duty and the company did its duty.

Mr. Stuart Wood: In view of the fact that this Florida decision is so comparatively recent and that it has been followed by decisions in North Carolina and in Kentucky, I am sure it would be very interesting to Mr. McFarland and possibly other members of the convention, if there is any gentleman here from North Carolina or from Kentucky who can tell us how the companies there have succeeded in protecting themselves or safeguarding themselves against the results of what seems to us very bad law.

Mr. W. S. Cramer: Mr. President and Gentlemen, I represent a privately owned plant at Lexington, Ky. We have had about a four years session in the court because of suits brought by citizens for loss of property; but in our case there was never anything settled. I believe we had the better legal talent, and had a little better of the fight. One case after a decision against the company was taken to the court of appeals of the state, where the decision of the lower court was reversed and remanded for retrial, and the case came up again on the strength of the pleading that our lawyers had made in the court of appeals. The lawyers for the plaintiff became sick of the case, possibly because the case was taken on a contingent fee. Our case in particular was settled for a monetary consideration, and taken out of court. It had cost our company about $6000 as far as we had gone, and they offered a monetary consideration to the firm that were representing the plaintiff on contingent fee, and being rather sick of their bargain it was settled in that way. That was a peaceful settlement so far as our companies were concerned. But there are other cases in other cities, Georgetown, Ky., particularly, where they have some three or four judgments against them; one for about $11,000 and two others for possibly $2000 to $3000 each. They are going to be taken to the supreme court of the United States, if one case has not already been taken there. In fact, I think, only one of them has as yet gone through the state court of appeals.

MR. CHESTER R. MCFARLAND: In regard to the case that was carried up from the supreme court of North Carolina and was known as the Guarantee Trust and Deposit Company vs. Fisher, and reported in 200 United States, 57, it appears that Judge Brewer took subject matter that was not before the court for consideration. The only subject that was then before him for consideration was whether or not a judgment in tort had precedence over first mortgage bonds. He was not satisfied to pass on this question, but it seems to me that he went out of his way to state indirectly that water companies were liable for damages if they neglected to furnish pressure.

Since writing the paper for the Convention, there have been several cases that have been decided in favor of water companies. The only case that has been decided adversely has been in the State of North Carolina which seems to adhere to its previous ruling in these cases.

Since writing the paper, in the case of A. C. Woodburry vs. Tampa Water Works Company, the attorneys for the plaintif applied to the supreme court of the State of Florida for a re-hearing. The court has rendered a very voluminous decision in denying this application, and it is one that persons interested in this line of thought should read. This case has been reported in the advanced sheets of the Southern Reporter, Vol. 49, No. 8, pages 556–566.

MR. J. M. DIVEN: The experiences that have been related will serve as a warning to any private water company that such gauges as referred to by Mr. Hague are very valuable in cases of this kind.

MR. W. S. CRAMER: They are not worth much before a farmer jury. We had three recording gauges on different parts of the system. The jury however seemed to ignore that evidence entirely. They thought the fellow had burnt out and as he didn't have any insurance there ought to be some help for him somewhere.

MR. WILLIAM H. BRYAN: There was a decision recently in the St. Louis court of appeals in a case against the Cape Girardeau, Mo. Water Works to the effect that a third party could not recover because a municipality is under no obligation to furnish fire protection to its people.

MR. C. A. HAGUE: In regard to the reference made by our friend from Kentucky about not taking the evidence of the recording gauge into court, such a failure to produce valuable evidence looks very much like an oversight on the part of the water company, because the courts as a rule will very carefully consider such evidence.

MR. W. S. CRAMER: We did have the evidence. We had charts from three recording gauges, one checking against the other; but they entirely ignored them on the ground apparently, as I stated before, that some one should pay the loss—or at least this is what seemed to crop out afterwards. In one case the fire started in a cooper shop, and one juryman was asked afterwards as to how they arrived at their decision. He said the building was worth $2400 and they gave a verdict for $800. That is the case that went to the state court of appeals. In asking those men how they arrived at that amount, they said they just charged the water company with the value, as near as they could get at it, of the property that was still left standing when the fire department got there! You know what a cooper shop fire would be. They charged us up with $800. This they estimated the value of the property still unburnt when the fire department got there.

MR. J. M. DIVEN: Why Mr. McFarland entitles his paper "Liability of *water companies*, etc." I do not know, for I can see no reason why all the conditions do not similarly affect a municipally-owned works. Why the municipality should not be held liable by the insurance companies or by a citizen for failure to furnish sufficient water to extinguish fires just as much as a water company. It would seem to me that the insurance companies would have a better case against the municipality. They would certainly have a more reliable opponent so far as paying the loss was concerned, for all water companies are not able to pay heavy awards for damages. Almost any city's liability would be sufficient to meet any ordinary fire loss.

Is not the liability of the city, if there is a liability in either case, more direct and more easily proved than the liability of a water company? A water company is furnishing water for fire protection under contract; it is furnishing water to a given number of hydrants and under a given pressure, and could not be held liable for a deficiency in the number of fire hydrants or a pressure more than the contract required. Whereas the city has no such limitations. The citizens are providing their own fire protection and if they do not provide ample protection they are certainly to blame.

I do not know of an instance where a municipality has been sued either by a citizen or by an insurance company for not furnishing sufficient water to extinguish fires, but I do believe that records would show that such deficiency has existed with municipally-owned plants, quite as frequently as with water companies.

THE SANITARY CONDITION OF THE SOUTHERN END OF LAKE MICHIGAN

J. HERBERT BREWSTER

Hardly more than fifty years ago the sanitary condition of the southern end of Lake Michigan offered no problems. The lake was a body of pure water and, save at a few widely separated points where cities were springing into existence and commercial life was developing, its shores were uninhabited and its waters undisturbed by shipping, while even at those places household sewage and industrial waste had not become a sufficient nuisance to demand its destruction. The time came, however, when these wastes had to be gotten out of the way and naturally enough the great body of water lying just at hand, seemingly capable of receiving and destroying any amount of sewage at no expense whatever, became the dumping ground.

When the growing cities could no longer depend upon ground and surface waters for a supply, just as naturally they turned also to the great lake for water, and now for many years they have been pouring sewage into Lake Michigan through one pipe and pumping out a water supply through another.

Is it not strange that, in this country, at least, the development of our national resources, the building of cities, the creation of great industries, has always meant destruction of the natural purity of lakes, stream and underground water? But such has been the case and today the cities along Lake Michigan are awakening to the fact that their most valuable civic asset, a pure water supply, is in great danger of being destroyed, and that already they have sacrificed hundreds of lives on the altar of ignorance and carelessness and wasted at the sick bed and cemetery far greater resources than would have preserved their water supply in its pristine purity.

The shore line of Indiana along Lake Michigan is very short compared with that of other States, but what Indiana loses in miles of coast is made up in other ways. Nearly all of the extreme southern end of the lake, with its burden of sewage and shipping, adjoins Indiana. And as the industrial march of Chicago progresses to the south and eastward, mile after mile of shore is losing its sandy beach and taking on the aspects of commercialism. Already Indiana's cities extend from Michigan City to Chicago and within fifteen years will have a greater population than is gathered at any other point on the lake save at Chicago herself.

The questions of pure water supplies and sewage disposal are more closely interdependent here than is the case with river cities which may suffer from the sewage discharged by upstream cities, but whose water is not usually affected to any great extent by its own wastes. And the problem is not to be solved for the benefit of the lake cities alone. The conservation of the purity of the southern end of Lake Michigan is in the near future to be a factor in the development of all northern Indiana cities. These cities are now depending upon deep well supplies, but it is only a question of time when, because of the failure of the underground water to meet the demands of an increased population, they too will be obliged to go to the lake.

It has been known for many years that the quality of the water of Lake Michigan was constantly being injured by the continued addition of domestic sewage and trade waste from every city and industry on her shores. The concentration of this dejecta of civilization at the larger cities has compelled the continued extension of water intakes farther and farther into the lake in an effort to reach pure water outside the zone of pollution.

Some years ago the city of Chicago found it was not longer possible to sewer into the lake and depend upon it at the same time for a water supply. The death rate from intestinal diseases due to polluted water was even then far above normal and a change of either the water supply or sewage disposal became imperative. The problem was in part solved by the construction of the Chicago drainage canal, which diverts the sewage of a large part of the city of Chicago from the lake into the Illinois River, through which it flows to the Mississippi and thence to the Gulf of Mexico. After the addition of sewage to the lake was discontinued the polluted area around Chicago began to diminish in size until at the present time the four-mile cribs supplying the city are obtaining a good quality of water and the water at the two-mile cribs is unwholesome only part of the time.

That the new system of disposing of the sewage has been a benefit to the city, is readily shown by the gradual lowering of the typhoid fever death rate, and also by the fact that the prevalence of typhoid fever in Chicago is less than in neighboring cities. For instance, it is claimed by the City Board of Health of Hammond, Indiana, that that city, with its 24,000 population, had this last year half as many cases of typhoid fever as the whole city of Chicago, with a population one hundred times as great.

Chart No. 1 was plotted from the statistics furnished by the Board of Heatlh, showing the death rate per 100,000 in Hammond, Whiting and East Chicago from 1903 to 1907 inclusive. While it is of little value owing to the short period that it covers and the failure on the part of the doctors to report the cases, yet, as this error lowers the death rates instead of increasing them, the chart is to be considered.

Hammond in 1903 had a death rate of 140; it then dropped to 80 and in 1905 reaches 66 per 100,000, which is the lowest point for the last five years.

Whiting does not show any returns until 1904, when the rate was 55 and then drops again until there is none in 1907.

East Chicago has no deaths in 1903. In 1904 it has a rate of 55, dropping again in 1905 and 1906, but in 1907 reaches 160. This is probably due to the records being more completely kept than in the previous years rather than to the great increase of typhoid fever.

It has been accepted as a general rule that a continued typhoid death rate above 20 is an indication that something is at fault with the public water supply. As is shown here, for the last five years the death rate of all three of these cities has been more than double this figure and has several times been six and eight times greater than this limit of safety.

Recognizing the fact that these cities, which are rapidly growing into what will undoubtedly be one of the greatest business sections of the world, will suffer serious material injury and eventually be compelled, as was Chicago, to devise some means of keeping down this typhoid fever loss, the health

Chart No. 1.

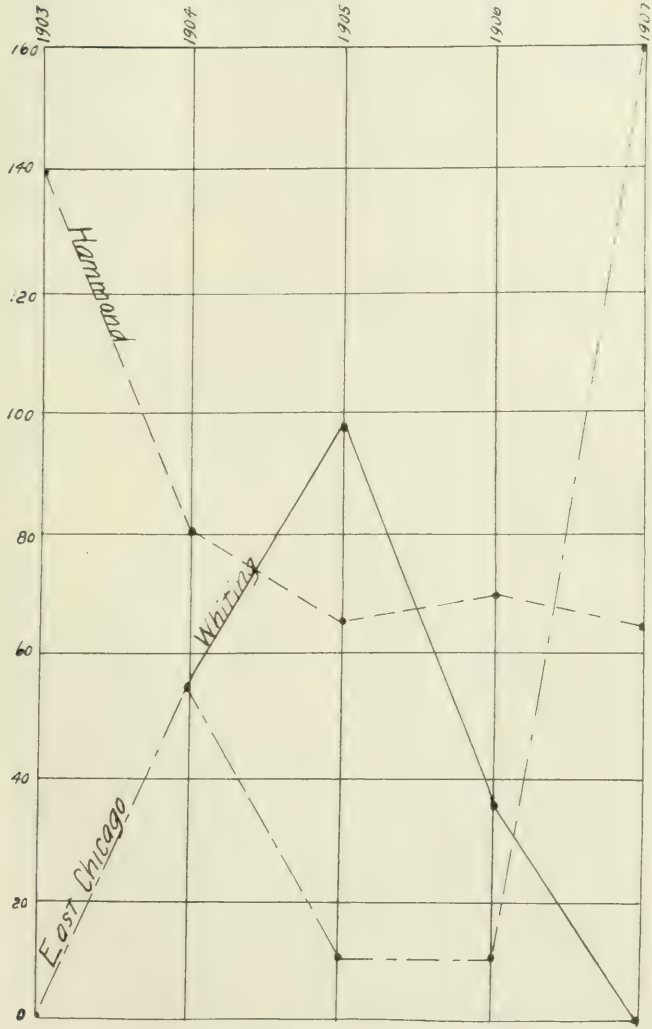


Diagram Showing Typhoid Death Rates per 1,000,000 in Lake County Ind. from 1903 to 1908 officers of Hammond, Whiting and East Chicago in the summer of 1908 requested the State Board of Health to make a sanitary survey of the lake near those cities, with the following objects in view: (1) to determine the real character of the different water supplies with respect to their present sanitary condition; (2) to determine the amount and character of the sewage entering the lake; (3) to determine the distribution of this sewage in the lake under the different prevailing winds and lake currents which occur along the lake frontage of these cities; (4) to study the probable future quantity of the sewage and suggest suitable means for its disposal.

In accordance with the request of the local health boards, on August 13, 1908 the State Board of Health established a temporary bacteriological laboratory equipped for making colony counts and the presumptive test for B. coli.

Forty-seven sampling points covering a territory of five miles off shore from Indiana Harbor to the Chicago two-mile crib off Brighton Beach were located and marked by buoys. Samples were taken daily at these points from August 19 to and including September 26.

The sampling points were located so as to establish a line of limitation of sewage distribution straight into the lake from each water intake; at every sewer outlet and on a diagonal in each direction from the mouth of each sewer. From a careful study of the bacterial content of the water at these points on different days with varying winds it was possible to determine the quality of the sewage entering the lake and how far it was carried in any direction, and also to gain a substantial idea of the prevailing currents and counter-currents. Chart No. 2 shows each sampling point with the number used to indicate it. Samples were taken from each intake and at each mile point in a line N. 23° E. for five miles into the lake; at the mouth of the Indiana Harbor sewer and one mile from it N. 23° E.; at the mouth of the harbor of the Inland Steel Company's plant and one mile from it N. 23° E.; at the Standard Oil Company's sewer, one mile from it N. 67° E. and one mile from N. 23° W.; at the mouth of two sewers, one a 36-inch sewer from Whiting and the other a 36-inch sewer from Robertsdale, at a point one mile N. 67° E. from these sewers; at the mouth of the Glucose sewer, one mile N. 23° E. and one mile N. 23° W.

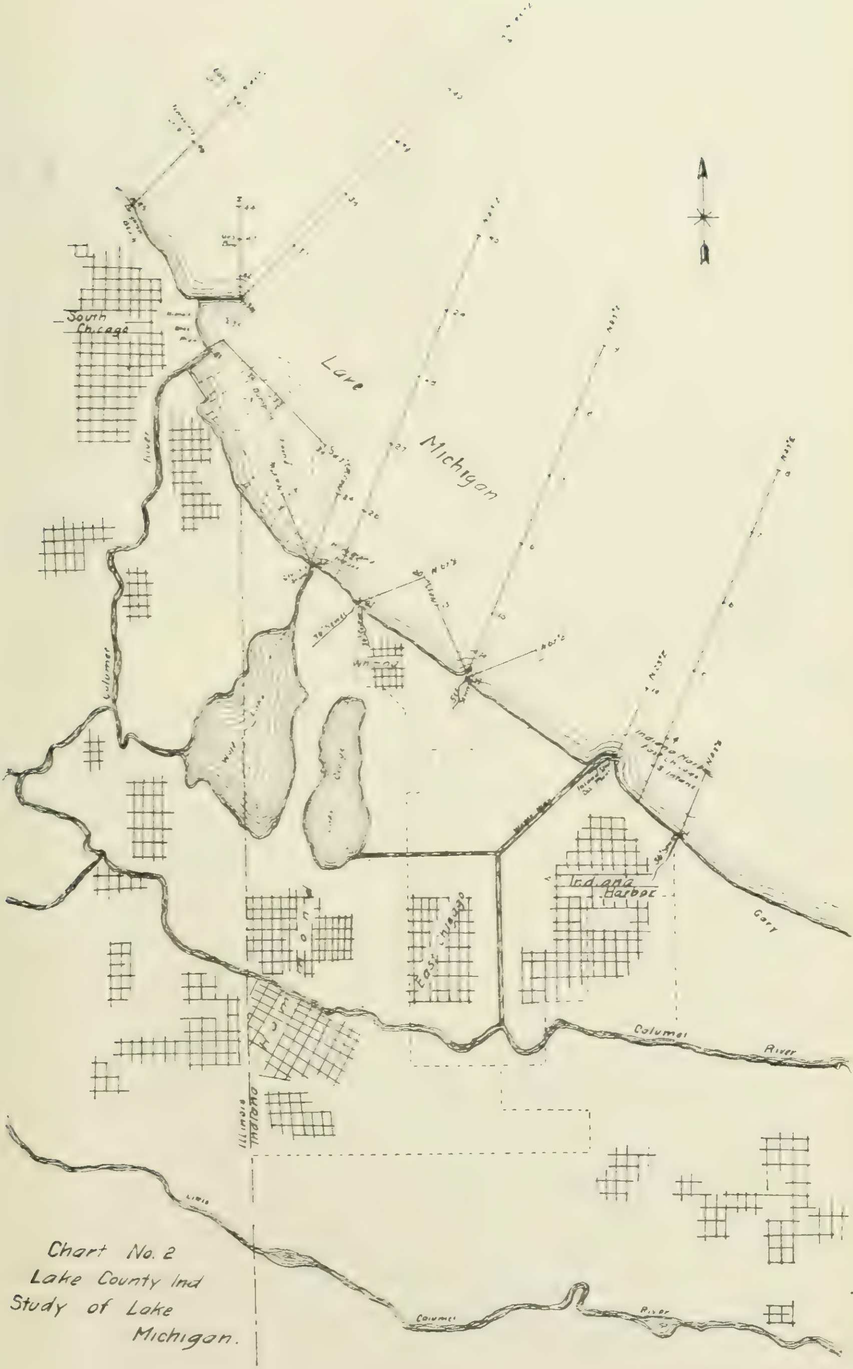


Chart No. 2
Lake County Ind
Study of Lake
Michigan.

from the Glucose sewer; at the mouth of the Calumet River and at points one-half mile, one mile and two miles S. 23° E. from the lighthouse and the government foghorn; at the government foghorn and every mile for five miles in a line N. 45° E. This point, which is No. 41, is practically seven miles N. 23° E. from the Hammond intake. Points were located at one-half and one and one-half miles north from the foghorn and at the government gas buoy; at Brighton beach bath-house, the temporary crib for the construction of the new water works tunnel and at the 68th Street crib.

The direction and velocity of the wind and the direction of lake currents and counter-currents were noted daily. The investigation necessitated the collection and bacterial analysis of 606 samples of water, and several chemical analyses of samples taken from different points in the lakeand from the city supplies. All lake samples for bacterial anlaysis were collected from a water level 10 feet below the surface. Since there are practically no wells throughout this section of the State the only source of supply is the lake.

THE DRAINAGE OF THE CALUMET REGION

The southerly end of Lake Michigan bordering Lake County is affected by the drainage of the Calumet River and of Wolf Lake, which receives the sewage of the Glucose works, and by the sewage from Whiting, East Chicago and Indiana Harbor. The character of the lake water will shortly be influenced to a greater degree than at present by the opening of a canal waterway which will connect Lake George and the Calumet River with the lake at Indiana Harbor. The Grand Calumet River is a tortuous channel which has its origin in Lake Michigan and after running through Lake County empties back into the lake. One end is about three miles east of Gary and the other terminates east at South Chicago. However, at the present time the mouth of Gary is closed by a sand dune, thus leaving but one outlet at South Chicago. The Calumet River, together with the little Calumet which empties into it near Hegewisch, Illinois, besides receiving the drainage of the northern Indiana cities and South Chicago, receives the drainage and storm flow of a great many small towns in Lake County and in the Illinois territory lying south of Chicago.

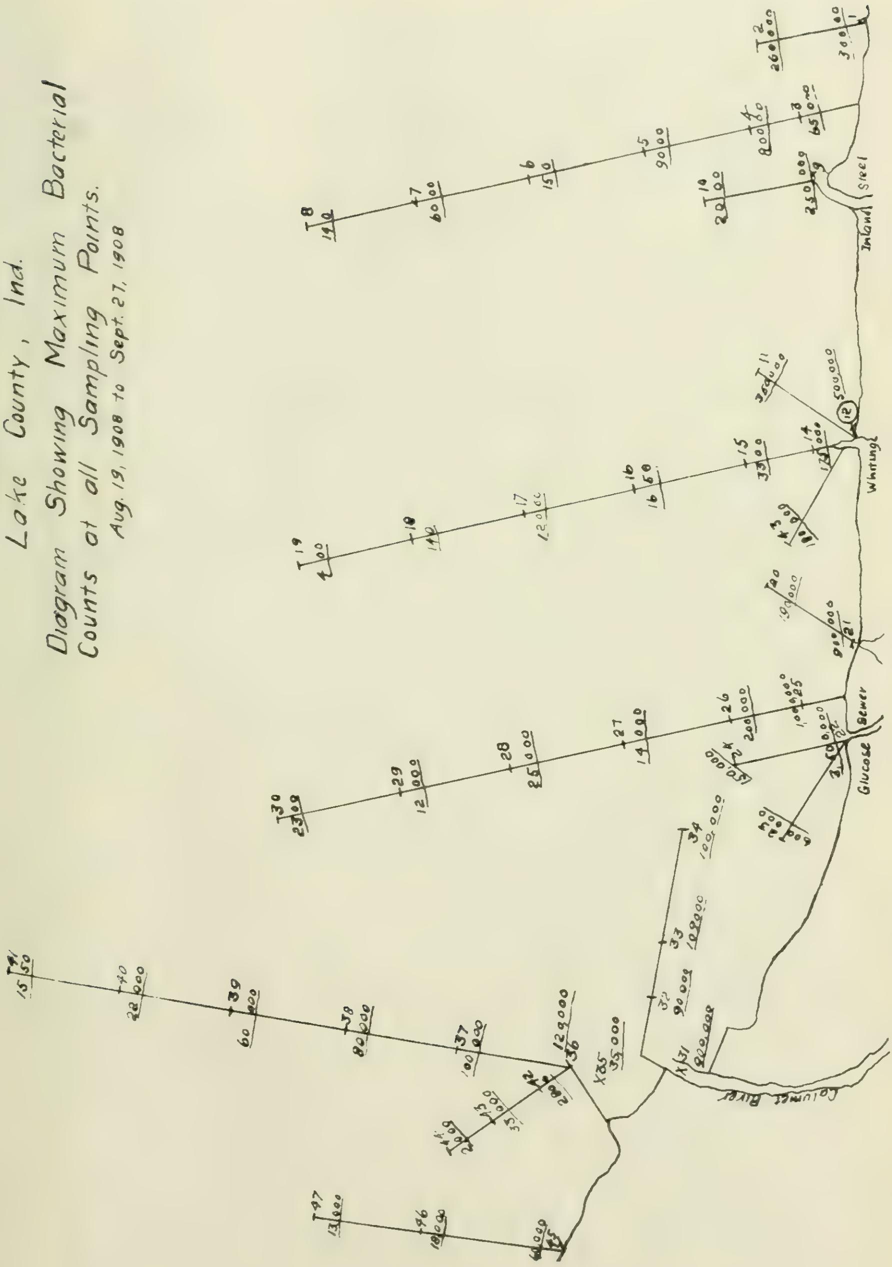


Chart No. 3
Lake County, Ind.
Diagram Showing Maximum Bacterial Counts at all Sampling Points.
Aug. 19, 1908 to Sept. 27, 1908

THE LAKE CURRENTS

As the outlet of the lake is small in comparison with the quantity of water it contains, there is no direct flow in the lake and the movements of the water are entirely dependent upon local winds which vastly overbalance the general movement of translation and drive the water one way or the other according to their direction, velocity and duration. The atmospheric temperature also influences these movements, and near the mouth of large streams, these, too, have their effect.

The friction of the wind blowing over the surface of a large body of water tends to produce a surface current of the water in the same direction, and if the wind continues to blow from one direction a general surface drift of the water in that direction is established. These induced currents may be interrupted at times or even reversed, but as a whole they represent an advance movement in the direction of the prevailing winds. It is the general impression that the prevailing currents are from the west to east along the southern shore of the lake and from east to west along the northern shore or counter clockwise around the entire lake, and water works intakes in some instances have been placed with the idea that these currents would act as a protection to their water supply. This idea is pronounced a fallacy by Major W. V. Judson, Corps of Engineers, of the War Department, who has found no positive currents in Lake Michigan and after a careful study of the Lake Currents concludes that they may run in any direction at any time according to the direct influences of the wind and atmospheric temperature.

Currents have been noted at the Hammond water works where the sewage from the Glucose works goes into the lake and is carried by a current from west to east. In a short time it turns toward the shore and on reaching the shore is deflected from east to west until it again reaches the flow from the sewer, when it is carried over the original course, thus producing a whirlpool effect around the Hammond intake. Within the area covered by this circular current large quantities of the glucose effluent was always found. These counter-currents have been noticed not only near the shore but have been encountered five and six miles out into the lake on perfectly calm days when there was apparently no reason for the change in direction of flow. The government engineering crew on the U. S. S. Search, who were making a survey of the bottom of the lake from Gary to South Chicago at the time of this investigation, stated that as many as three distinct currents going in opposite directions have been found within linear distance of two miles, and that these currents were apparently stronger on a calm day than when the lake was rough.

A probable reason for these currents at this point of the lake is that the frontage of Hammond, Whiting and Indiana Harbor is in what might be called a "pocket" lying between the Gary Harbor and South Chicago, and that currents caused by southwesterly winds, starting for instance at South Chicago, would strike the projection at Gary and be compelled to return against the direct wind current.

The Grand Calumet River, owing to its large drainage area, discharges some water into the lake practically all of the time, but with strong northerly winds a decided current up the harbor has been observed. While the natural appearance of the river water is very turbid at such times, the appearance of the water in the mouth of the harbor is the same as that of the lake water. During flood times and when off-shore winds prevail the river water has a high velocity and streams of murky water can be seen in the lake for several miles out, reaching to the west as far as the Hyde Park crib of the Chicago Water Works with the easterly currents and to the east in front of Hammond with the westerly currents. That the effluent of the Calumet River reaches these points is shown by the bacterial counts of August 31 on Chart No. 4 and on September 5 on Chart No. 5.

The current distribution is shown on Chart No. 4 to carry sewage from the Glucose works five miles into the lake where point No. 30 has 300 bacteria per cubic centimeter. On Chart No. 5 when the sewage of September 4 is being carried by westerly currents point No. 25 off Hammond has 6000 bacteria. Point No. 26 or one mile from shore has 85,000 bacteria and point No. 27 or two miles from shore has 2000 bacteria; point No. 17 or three miles from the Whiting shore has 12,000 bacteria, which is in direct contrast to points Nos. 16 and 18, which have 6 and 10 bacteria respectively. Point No. 7, four miles from shore off Indiana Harbor, has 6000, which is contrasted against

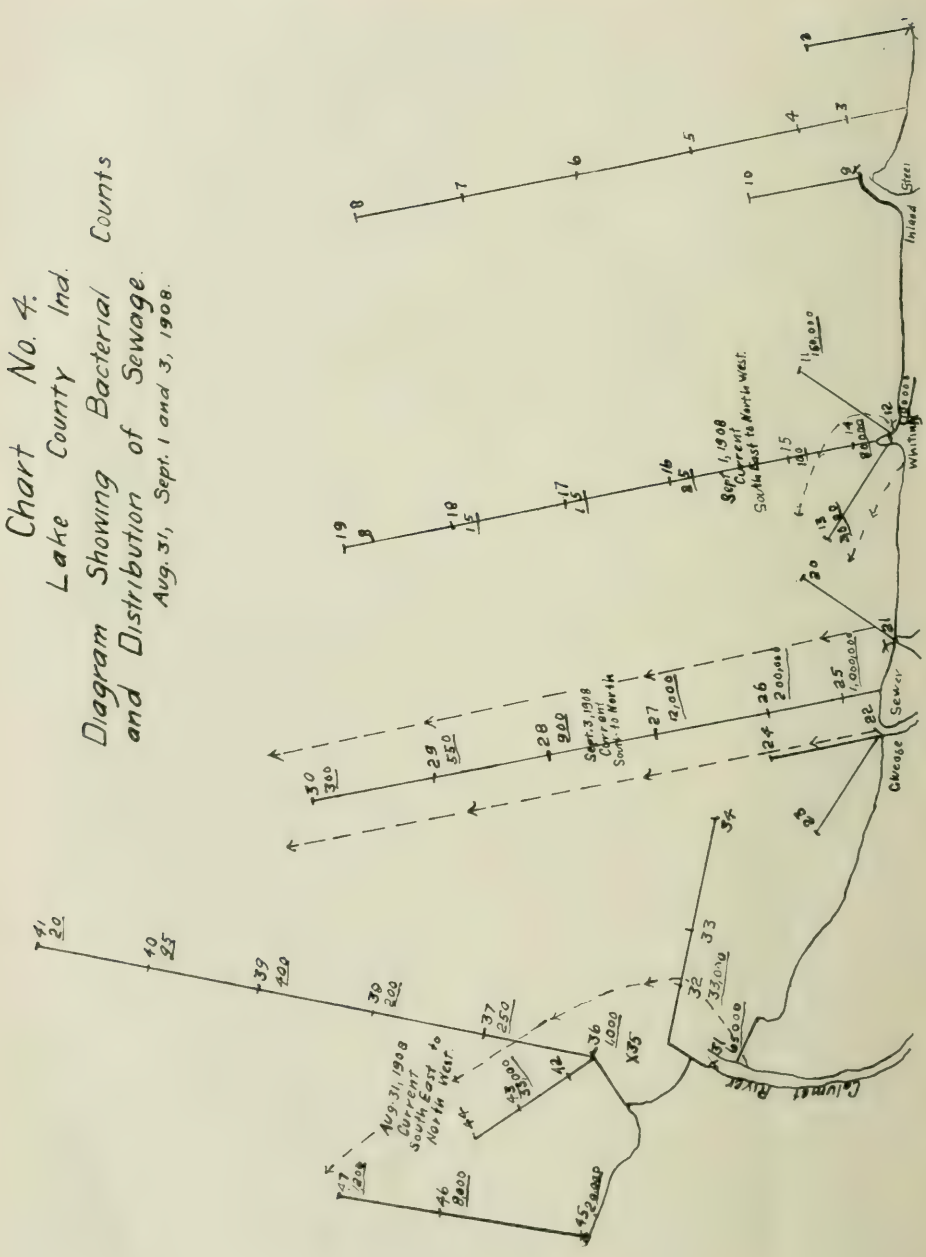


Chart No. 4.
Lake County Ind.
Diagram Showing Bacterial Counts
and Distribution of Sewage.
Aug. 31, Sept. 1 and 3, 1908.

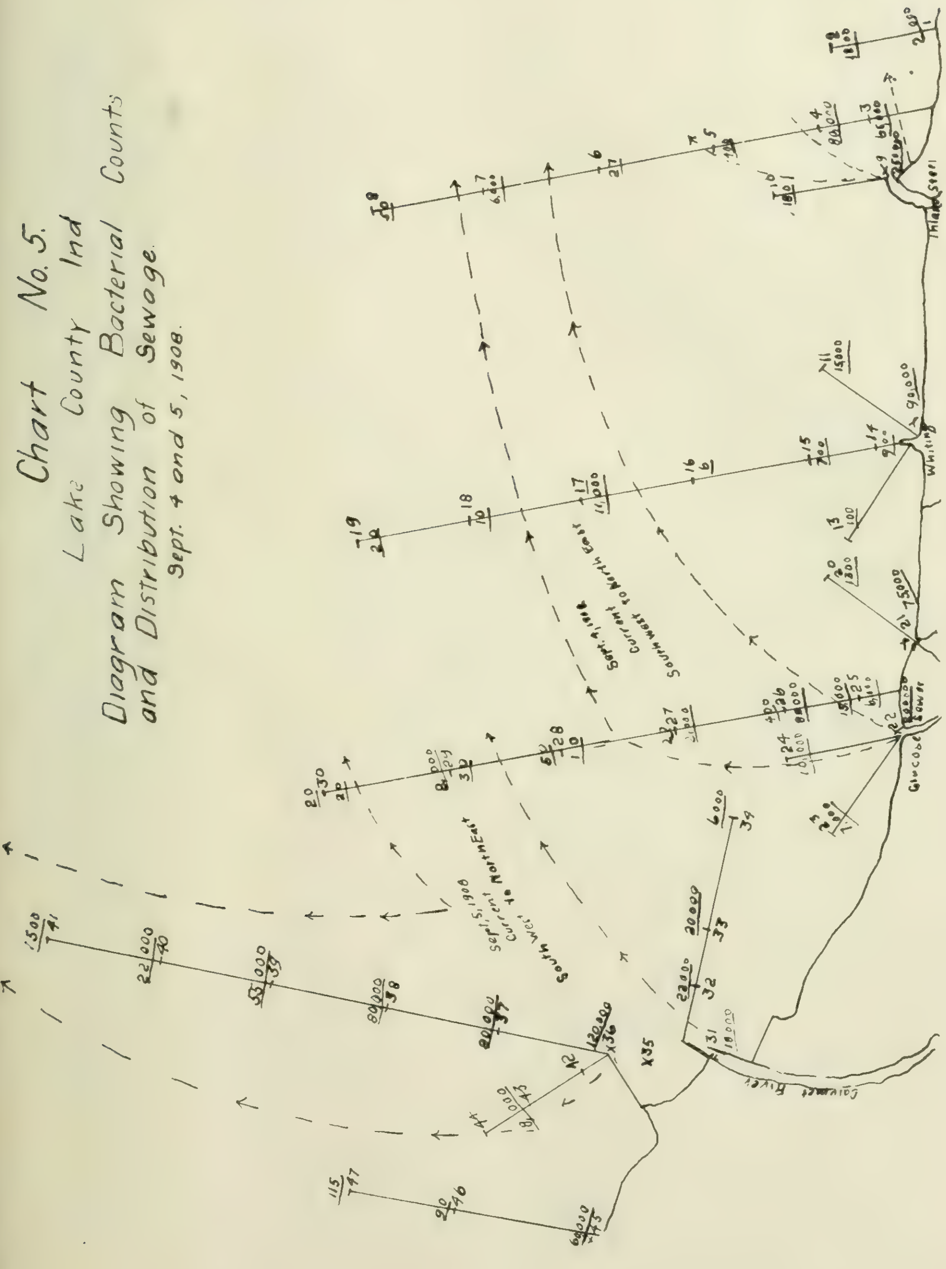


Chart No. 5.
Lake County Ind
Diagram Showing Bacterial Counts
and Distribution of Sewage
Sept. 4 and 5, 1908.

Sept. 4, 1908 Current to North East
South west
Sept. 5, 1908 Current to North East
South west
Whiting
Inland Steel
Calumet River
Glucose Lower
X35

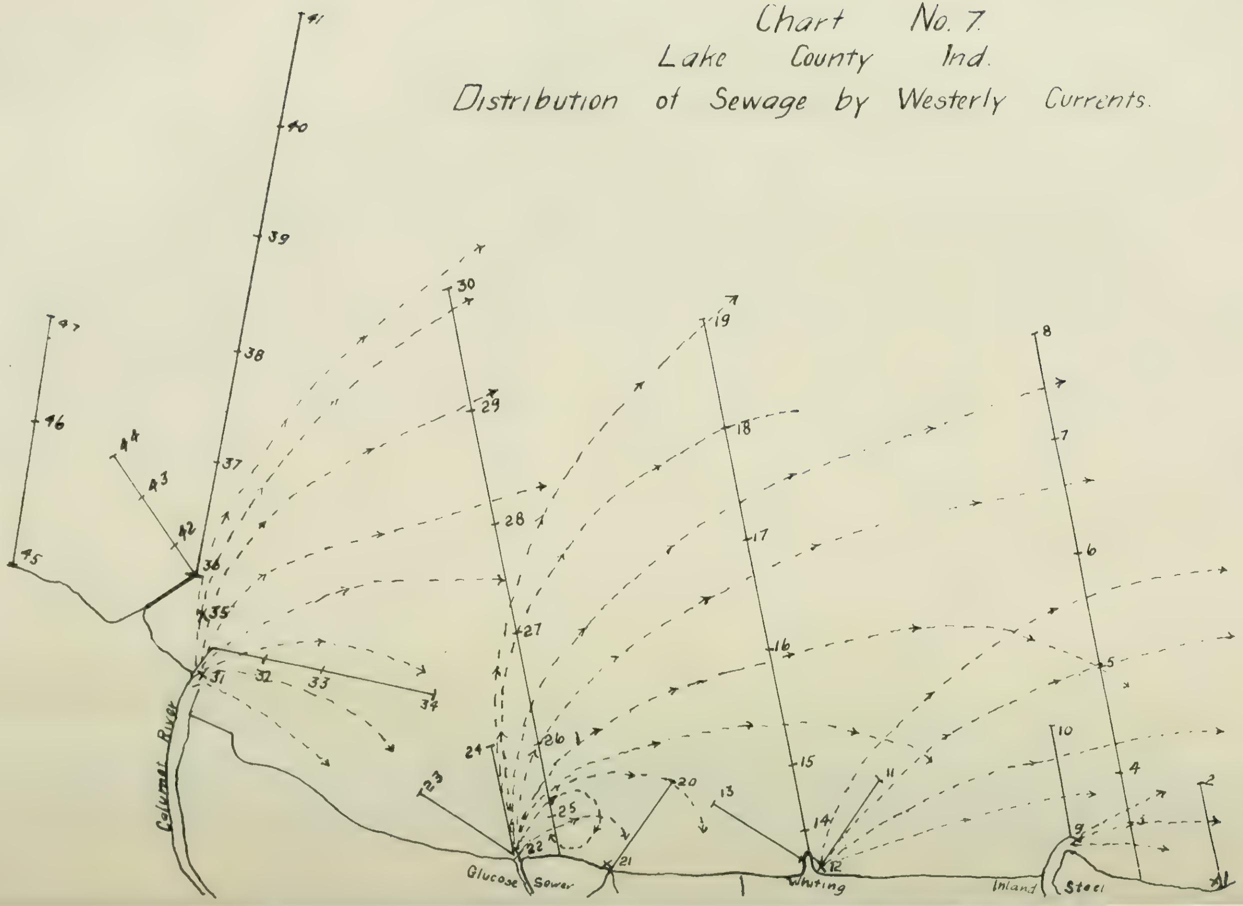


Chart No. 7.
Lake County Ind.
Distribution of Sewage by Westerly Currents.

Chart No. 8.
Lake County Ind.
Distribution of Sewage by Easterly Currents.

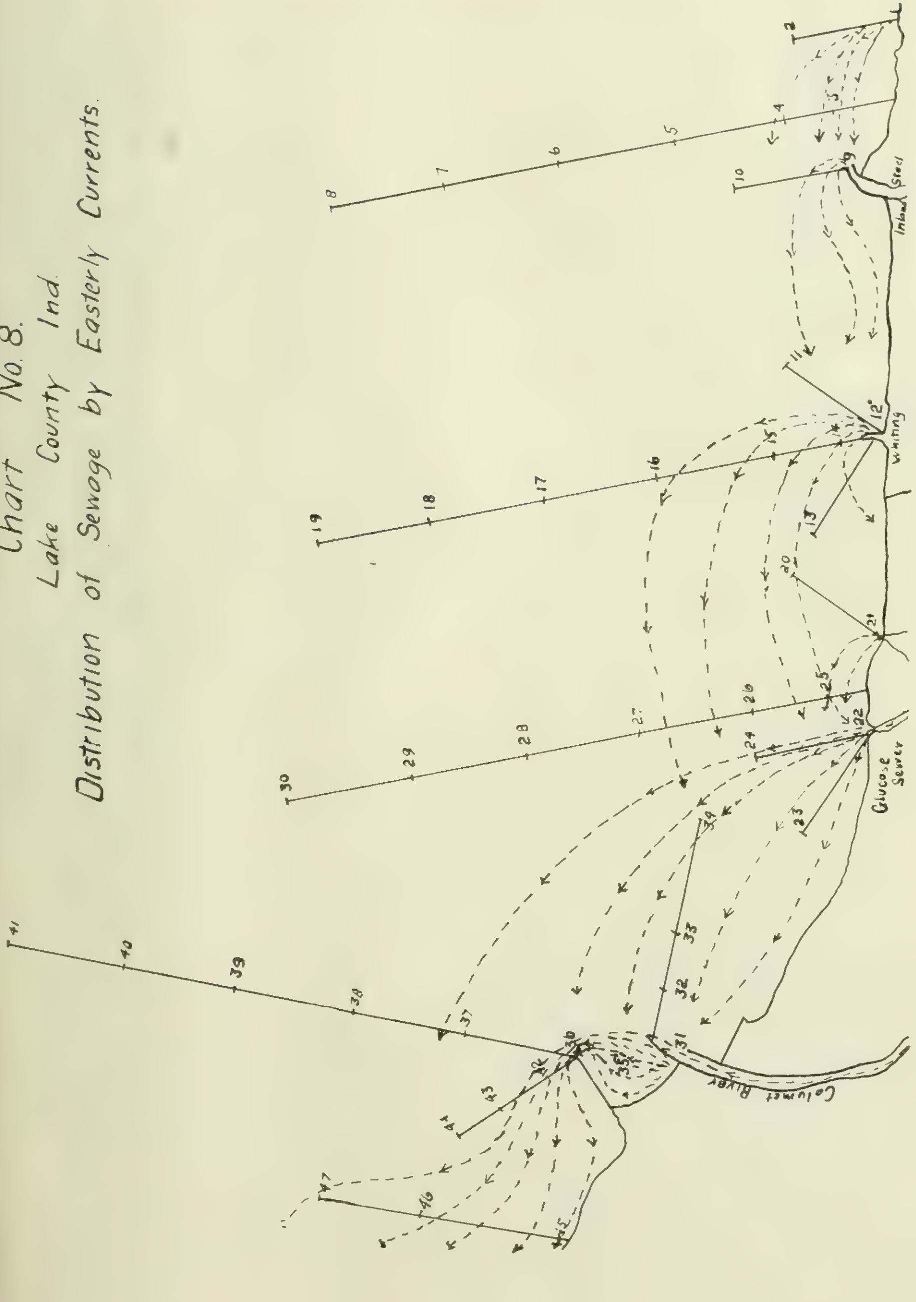
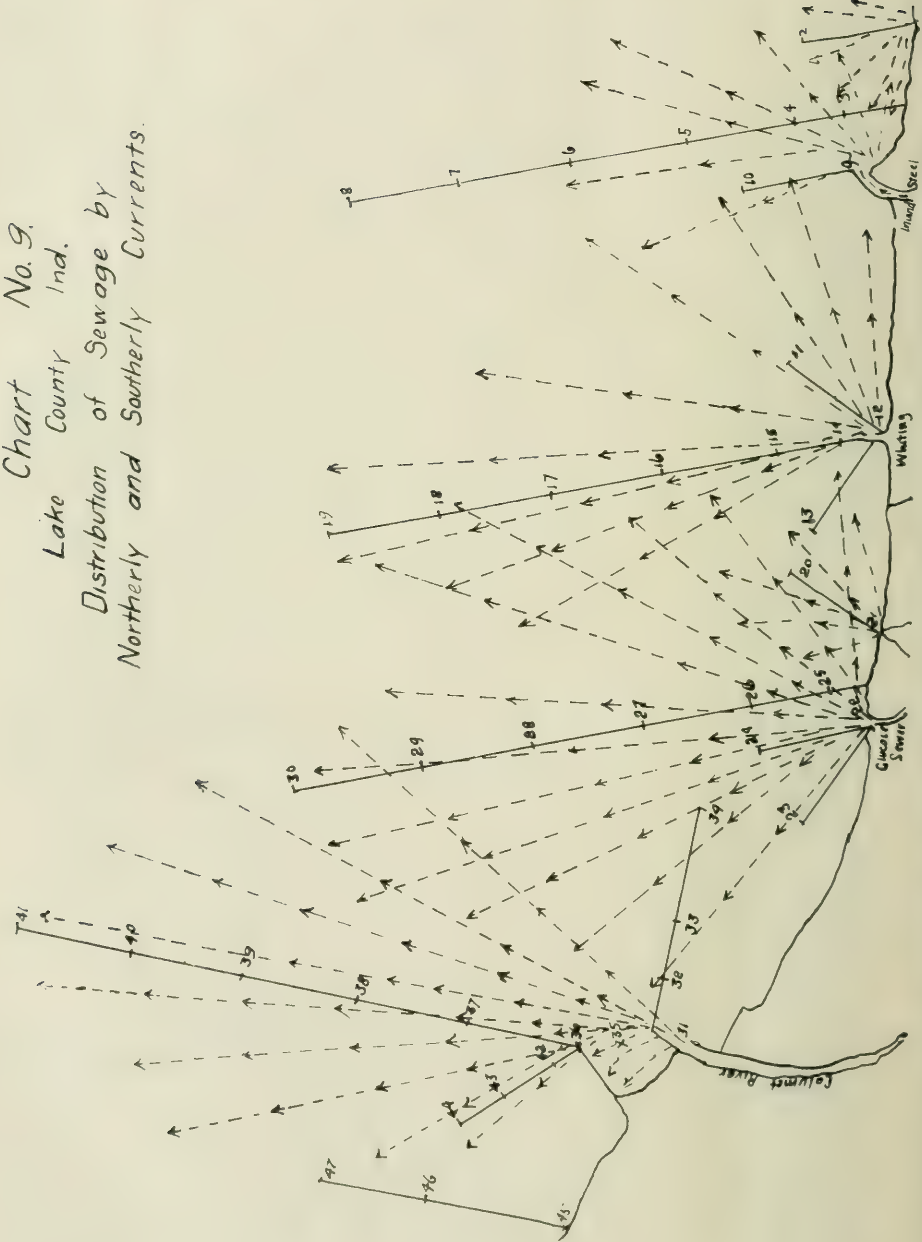


Chart No. 9.
Lake County Ind.
Distribution of Sewage by
Northerly and Southerly Currents.



point No. 6 with 27 bacteria and point No. 8 with 50 bacteria. This chart shows a distinct current from the Glucose sewer passing over the one-mile point at Hammond, the three-mile point at Whiting and the four-mile point at Indiana Harbor. This shows conclusively that the effluent from the Glucose works is carried by currents for over ten miles into the lake. That the sewage from this plant goes west with easterly currents is difficult to show by bacterial counts, as the differentiation between bacteria from the Glucose works and those from the dumpings of dredged material in this locality, or from those brought in by currents from the Calumet River, is impossible, for points between the Hammond intake and South Chicago Harbor always show high counts. That the Glucose sewer does go in this direction is easily determined from direct observation, however, as the line of demarcation between the lake water and stream of sewage is often very distinct.

At Whiting the Standard Oil Company placed their five-foot sewer on the east side of the pier as a protection to the city water. That this is no protection is shown on Chart No. 4, when on September 1 there were 100,000 bacteria at the sewer, point No. 12, and 80,000 bacteria at point No. 14, the Whiting intake. On this date four-fifths of the water going to the people of Whiting was the discharge of the Standard Oil Company's sewer. With easterly currents the effluent from this sewer is thrown against the pier and follows along until it reaches the end, where it is but a few feet from the intake to which it is carried in a direct compact stream. In this way a more concentrated sewage is pumped to the people than would be the case if there were no pier to direct the flow. Oil is seen on the water at times as far west as the Hammond intake. This was especially noticeable on September 24. At other times the oil reaches to the east as far as the intake at Indiana Harbor. The water of East Chicago is affected by currents carrying the effluent from the Inland Steel Company's harbor, as is shown on Chart No. 5, in which point No. 9, the mouth of the harbor, has 250,000 bacteria, while 65,000 bacteria are carried by westerly currents to the intake at point No. 3. Observations made by following streams of sewage with a boat from the different places of entrance, shows the currents to go in the directions indicated on Charts Nos. 7, 8 and 9 according to the varying winds. These bacterial counts and observations are a positive corroboration of Major Judson's investigations, in which he found that currents may flow in any direction according to the prevailing winds.

Lake Michigan is very shallow along the shore bordering Indiana, and is at certain times rendered more or less turbid by reason of the deposits of clay being stirred up by the wind and currents.

The character of the water for drinking and domestic purposes depends very largely upon its freedom from organic pollution, especially in the form of household sewage. As to this point the water of Lake Michigan in its normal state approaches absolute purity and where supplied in this condition its quality is unquestionable. It was found that at Michigan City during July and August of 1908 the water one mile in any direction from the mouth of the harbor was practically sterile. Unfortunately the water intakes are close to shore and in many instances near the outlet of public sewers, as at Hammond, where the intake is only 2000 feet from shore, with two small sewers, one from Whiting and one from Robertsdale to the east and the glucose sewer to the west, all of which are within a radius of 3000 feet from the intake. At Whiting the intake is but 2000 feet from the shore and the same distance from the Standard Oil sewer. And at Indiana Harbor the intake is 3000 feet from shore and about 3500 from the mouth of the Inland Steel Company's harbor and the Indiana Harbor sewer. It therefore becomes necessary to determine whether or not the sewage that enters the lake is carried to the intake of the water supply in order to know the true character of the city water.

DISPOSITION OF THE SEWAGE

Indiana Harbor empties its sewage directly into the lake. This is principally domestic sewage, and as there was no rain during or for some time previous to this investigation there was no surface wash entering the lake at any time. The sewage of the city runs by gravity into a well from which it is pumped into the lake by an electrically driven pump through a 36-mile sewer line which enters the lake about twenty-five feet from shore at the foot of Lincoln Street. This point is about one half mile east of the water works intake pipe.

At East Chicago both the manufacturing and domestic sewage runs into the Calumet River.

The Whiting sewage flows directly into the lake through three sewer outlets. A 36-inch sewer empties at the same place as a sewer of similar size which takes care of the sewage of Robertsdale. These outlets are close to the boundary line between Hammond and Whiting. There is another 36-inch sewer about one-half mile east of this. The combined drainage of both sewers takes care of the domestic sewage and storm flow of Whiting with the exception of that portion of the land occupied by the Standard Oil Company's plant. The sewage from this plant enters the lake at the junction of the shore and shipping pier for the oil boats through a six-foot sewer which is 2000 feet from the intake of the water supply of the city.

At Robertsdale the Glucose plant disposes of its sewage through a private sewer to the mouth of Wolf Lake.

The city of Hammond discharges its sewage into the Calumet River. The system is arranged in districts with each district having an outlet into the river. The city lies so low that the sewers are below the level of the river and it is therefore necessary to deliver the sewage to pump wells from which it is lifted into the river. This system is satisfactory when the pump is in operation, but much inconvenience is caused when the pump is not running by reason of sewage backing up and overflowing into basements and cellars.

The Calumet River is in reality an open trunk sewer running through the cities of East Chicago and Hammond. In some places, notably at the distillery at Hammond, the volume of obnoxious decomposing organic matter is very great and becomes a public nuisance. The fact that this stream of sewage flows directly through the city of Hammond renders life along its banks unpleasant and even dangerous, as an excellent opportunity is afforded for flies to carry disease to the tables of private families and restaurants that are near its banks. The river is also a breeding ground for mosquitoes. The amount of sewage that enters the Calumet River is not known at the present time and can be determined only with great difficulty. For this reason it is impossible to estimate the amount of sewage that is being emptied into the lake by the river. That the quantity is at times very large is plainly shown by the immense streams of turbid water that are carried miles into the lake.

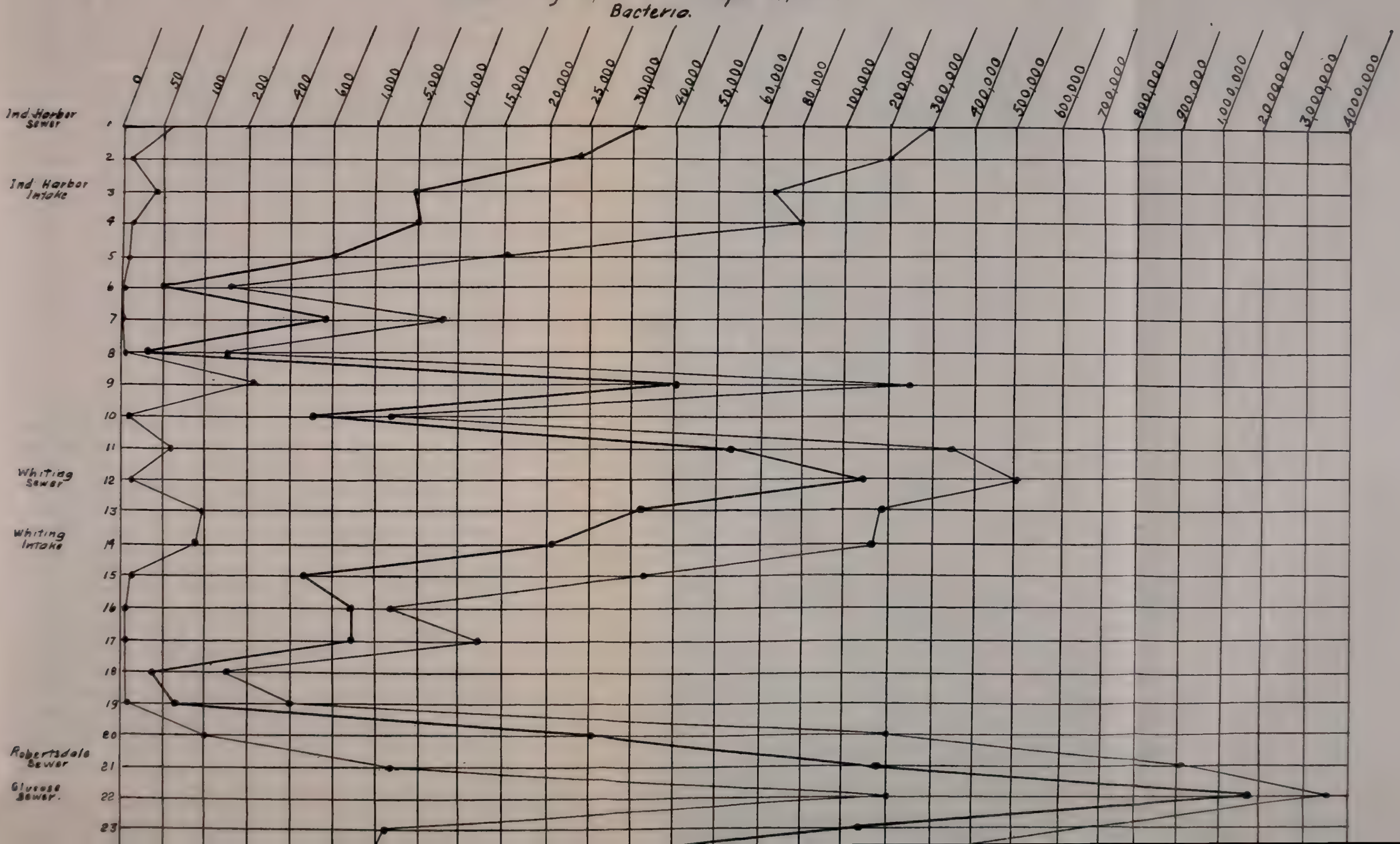
The amount of sewage entering the lake from the harbor at Indiana Harbor is comparatively small, but that it has its effect up in the lake water is shown by the bacterial analyses.

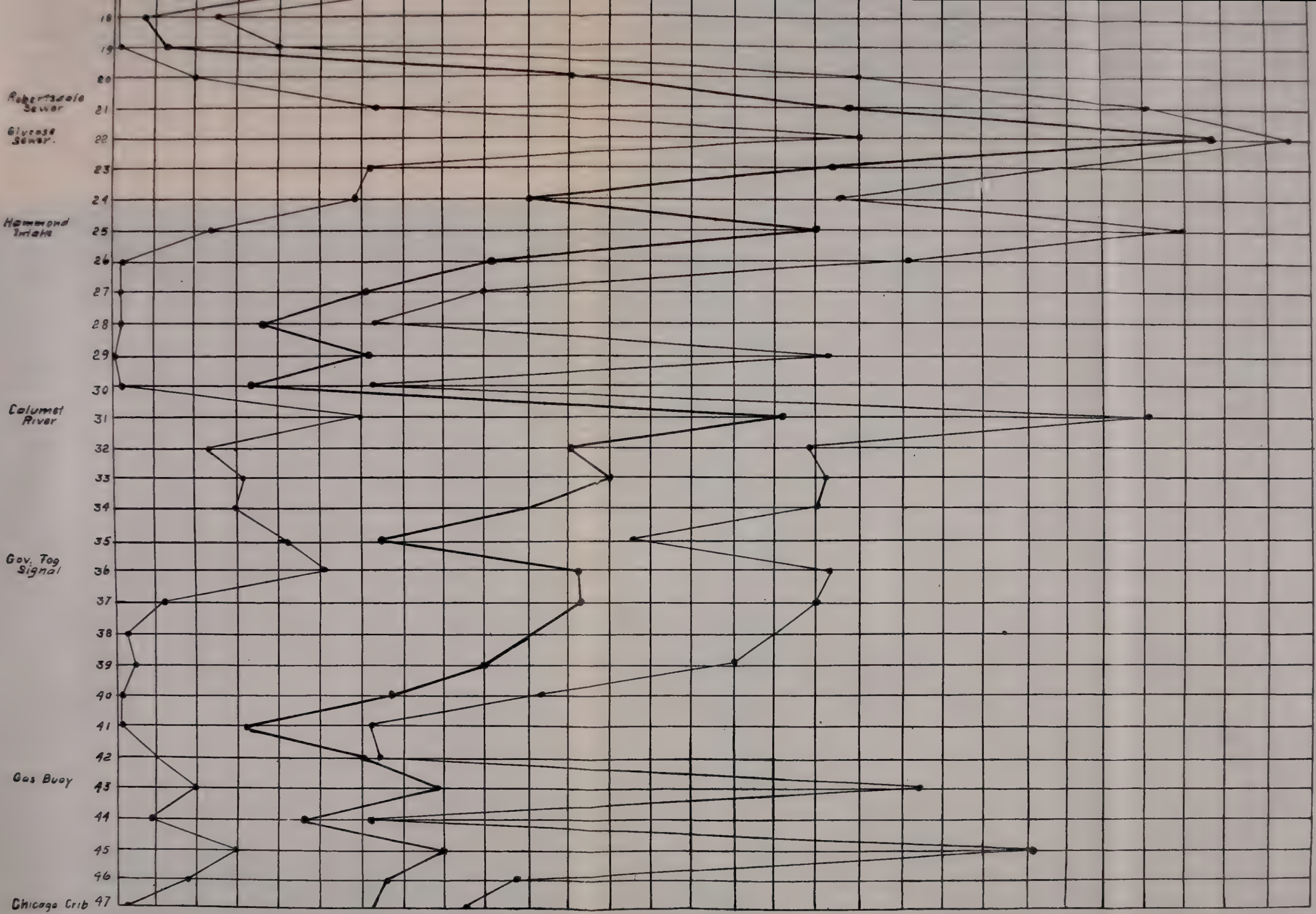
DISCHARGE OF LOCAL SEWERS INTO THE LAKE

The most important and most damaging of these sewers is that at the Glucose plant. The average daily discharge is about 2,300,000 gallons. The sewage is in the form of wash and steep waters used in the preparation of the grain and in the processes of manufacture. It contains large quantities of the nitrogenous principles of the corn and other ingredients which evidently form an excellent culture media upon which bacteria live and multiply. An analysis of the solid matter in the waste water showed a protein content of 36.30 per cent. It is most surprising that this valuable product is allowed to go to waste. At the mouth of the sewer the maximum number of bacteria observed was 3,500,000 per cc., the minimum 200,000 per cc., while the average number during the period of investigation was 1,811,000 per cc. with indications of B. coli always present. This bacterial content is by far in excess of that of the Calumet River, with an average of 86,480. The bacterial content is also much higher than that of the south fork of the Chicago River commonly known as Bubbly Creek, which receives the waste material of the stockyards and is considered one of themost, vile waters in this section. The average bacterial count shown at the stockyards filter plant was 500,000 per cc. An instance of the effect of this sewer upon the purity of the lake water is clearly shown on Chart No. 5 by the extreme bacterial count on September 4 at the four-mile point off from Indiana Harbor.

The waste water also deposits large amounts of the husk on the corn for some distance around the mouth of the outlet. This organic material, in a decomposing and putrefying condition, is found in quantities in front of the Hammond pumping station. An analysis of this débris showed a protein content of 12.9 per cent. As 45.4 per cent of this material was inorganic the actual protein content of the organic portion was 23.2 per cent.

Chart No. 10.
Lake County Ind.
Diagram Showing Maximum, Minimum and Average Bacterial Counts in Lake Michigan Water.
From Aug. 19, 1908 to Sept. 27, 1908.





18
19
20
Robertsdale Sewer
21
Glucose Sewer.
22
23
24
Hammond Intake
25
26
27
28
29
30
Calumet River
31
32
33
34
35
Gov. Fog Signal
36
37
38
39
40
41
42
Gas Buoy
43
44
45
46
Chicago Crib
47

The anchor line on the buoy marking the Hammond water works intake collected a large quantity of this refuse matter and was the only anchor line of all the sampling points that was not perfectly clean. The odor of putrefaction emanating from this sewer is noticeable for a considerable distance and at times with northerly winds passengers on trains passing through Robertsdale are made sick.

The streams of sewage from this source have a distinct color and the line of demarcation between it and the lake water is extremely sharp. A power boat passing through these streams leaves a line of bubbles on the surface marking the exact course traveled. When going in a direct current the sewage does not seem to mix readily with the lake water and the streams are very distinct until cross-currents are encountered.

The effluent from this sewer is the most damaging and the most far-reaching of any source of pollution along the Indiana lake front and under conditions now obtaining, the citizens of Hammond are being served with a nitrogenous broth under the guise of drinking water.

The two 36-inch sewers entering the lake at the Whiting and Hammond boundary line discharge an average of one and one-half million gallons daily into the lake. On account of the extreme dry weather, the amount of sewage entering the lake during the period of investigation was much below the average, and for this reason the bacterial counts were low and the sewage could not be traced for more than a mile into the lake. The 36-inch sewer at Indiana Harbor, which discharges about 1,000-000 gallons daily, showed exactly the same condition. The effect of these sewers will undoubtedly be much greater under reverse weather conditions, but cannot be compared with the effect of the Glucose sewer. The exact bacterial counts at these sewers could not be ascertained, as the outlets were too far into the lake to be reached from the shore and it was impossible to reach them from a boat on account of the shallow water. For these reasons the samples were collected about 50 feet in front of the sewer after much dilution had taken place.

The private 6-foot sewer of the Standard Oil Company, which discharges about 18,000,000 gallons daily into the lake, has an especially damaging influence upon the water supply of Whiting. As has already been shown there are times when four-fifths of the water supply of the city is composed of this sewage. The bacterial content of this sewage is often very low owing to the antiseptic influence of some of the refuse material, especially at times when it contains sulphuric acid. The minimum count showed but 10 bacteria per cc., but at other times the sewage was not benefited by these influences and the maximum count showed 500,000 per cc. The average during the period of investigation was 162,821 per cc.

SHORE WASH AND STIRRING UP OF THE BOTTOM

During storms and windy weather the bottom is stirred up by wave action and suspended matter is carried back and forth between the shore and the water intake. At such times any deposits like the débris from the Glucose plant and the dredgings from the Calumet River along the shore are carried out either by direct currents or by counter-currents in reverse winds and materially increase the turbidity of the water. While such material is usually innocuous, yet its peculiar character and the increased turbidity it gives the lake, often renders the water unsatisfactory for drinking purposes.

THE DUMPING OF DREDGED MATERIAL

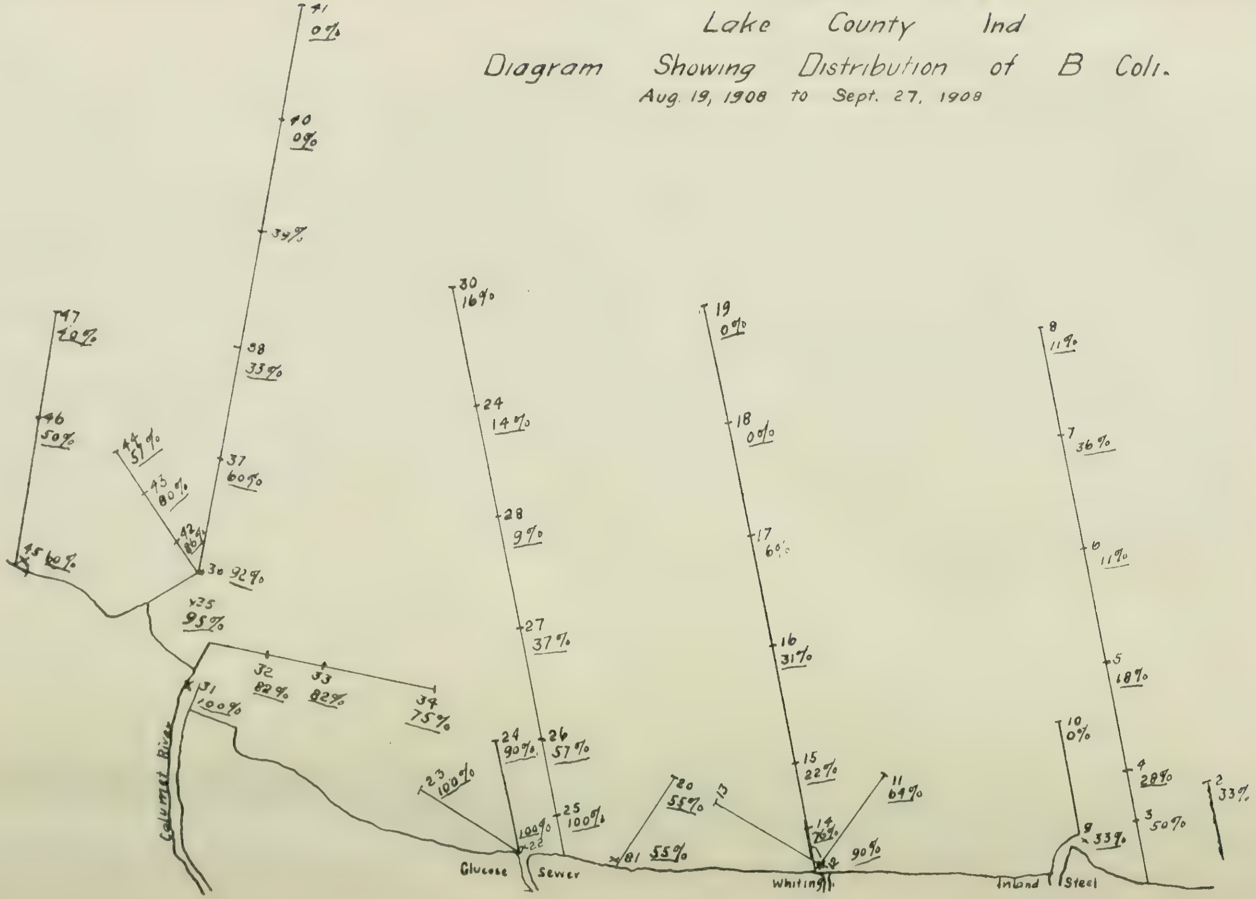
On account of the very sluggish motion of the Calumet River, the occasional up-stream currents and the large amount of silt brought into it, the Great Lakes Dredging and Dock Company are almost continually dredging out the bottom of the river in order that the required depth may be maintained for the big freight and ore boats to navigate. This dredged material is carried out in scows and dumped into the lake. This dumping ground covers the territory shown on Chart No. 2, reaching from the mouth of the Calumet River on the west in a diagonal line nearly to the Hammond intake on the east. The territory allotted for the dumping of this material is understood to be much smaller and much nearer shore. But it is stated by the Superintendent of the Hammond pumping station that there have been times when these scows were dumped within a few hundred feet of the Hammond intake. On September 22 two scows were emptied into the lake at Sampling Point No. 33, and on September 24 it was observed that two scows were dumped a few feet north of Sampling Point No. 32.

The effect upon the purity of the lake of dumping of this material is very damaging, as is shown by the high bacterial counts observed at points Nos. 32, 33, and 34, at all times without relation to the direction of the wind and current. This exceptional condition is obtained at no other lake points. The average bacterial count at point No. 32 was 34,322, at point No. 33, 30,385, and at point No. 34 it was 19,228. There were occasionally times during very calm weather when the bacterial count was quite low. The dumping of this material into the lake so close to Hammond intake is very liable to contaminate the city water, since particles held in suspension and water that is mixed with this material is carried near the water intake. This dumping should be carefully regulated since, as this material is principally clay and muck, the smallest particles will be carried great distances.

Chart No. 6 is a diagram showing the per cent of times that B. Coli was found at each sampling point. At the mouth of the Calumet River it was present 100 per cent; inside of the harbor 95 per cent; at point 36, which is the Government foghorn, was present 92 per cent. There is then a gradual reduction until, at points 40 and 41, B. coli was not found. Point No. 47, the 68th Street crib of the Chicago water works, showed Coli 40 per cent of the time. At the Glucose sewer and at the Hammond intake it was always present and at point No. 30, which is five miles from shore, is present 16 per cent of the time. The water at the Whiting intake showed Coli 76 per cent of the time. At the one-mile point we have 22 per cent; two-mile point 31 per cent the three-mile point 6 per cent, while four and five-miles from the shore Coli was not found. The water of Indiana Harbor shows Coli 50 per cent of the time and there are coli found at each point on the line of survey. The five-mile point shows Coli 11 per cent of the time. The reason for some of these points having a smaller amount of coli than others is undoubtedly due to elevations in the lake bottom which have a tendency to convert the currents of sewage away from these points.

In Chart No. 10 there is given a maximum, minimum and average bacterial count of each sampling point. The interesting feature in this chart is that point No. 7, which is four miles from the Indiana Harbor shore, has a lower bacterial count than either the three-mile or five-mile point, and that at points Nos.

Chart No. 6
Lake County Ind
Diagram Showing Distribution of B Coli.
Aug. 19, 1908 to Sept. 27, 1908



16 and 17, which are two and three miles respectively from the Whiting shore, the bacterial counts are lower than those at points Nos. 15 and 18, which are one and four miles from the shore, and again at point No. 29, which is four miles from the Hammond shore, the bacterial count is lower than either the three or five-mile points. That this is true is evidence that there is more or less of a continuous current of sewage running east and west at about four miles from the shore, coming both from the Calumet River and the Glucose sewer.

In summarizing the survey of the southern portion of Lake Michigan adjoining Lake County, the chemical and bacteriological examinations show the water of the lake to be grossly polluted and unfit for use as a source of water supply for drinking and domestic purposes.

This deplorable condition of a once pure and potable body of water is due to the great volume of sewage and manufacturing waste being poured into it by (*a*) the Calumet River, (*b*) the Glucose sewer, (*c*) the Standard Oil Company's sewer, (*d*) the sanitary sewers of the cities of Indiana Harbor, East Chicago, Whiting and that portion of Hammond known as Robertsdale, (*e*) the dumping of material dredged from the Calumet River.

There is no uniform current in this portion of the lake and sewage once deposited in it may be carried in any direction, depending upon (*a*) the direction and force of the wind, (*b*) the lake level, (*c*) the direction of temporary and induced currents.

The sewage from any one point along the shore may be carried over the intake of any of the water supplies. For this reason the abatement of any one nuisance will not afford a great measure of relief, as the remaining sources of pollution will be amply sufficient to render the water unsafe.

The laying of intakes farther into the lake will not provide an adequate protection against impure water, since the zone of pollution extends more than five miles from shore.

The character of the water of Lake Michigan is so well adopted for all domestic and industrial uses, that cities along its shore cannot longer afford to pollute it and to destroy it as a water supply. The discharge of all unpurified sewage of industrial wastes into the lake must be stopped and the former purity of the water regained.

No single municipality can hope adequately to handle the situation. The problem of a purified and permanently potable Lake Michigan can only be solved by the concerted efforts of every city on its southern shore, aided by the joint action of the states of Illinois and Indiana.

RECOMMENDATIONS

As the result of the study of the pollution of Lake Michigan and the condition of the public water supplies of the cities of Hammond, East Chicago and Whiting, we suggest the following possible means by which the situation may be remedied:

1. The installation of gravity or mechanical filters to purify the water of each of the present systems.
2. The installation of sewage disposal plants to purify the sewage or otherwise destroy the injurious bacteria now being poured into the lake.
3. Such action as will stop permanently the dumping of dredged material within five miles of any water intake.
4. The abatement of the nuisance known as the "Glucose Sewer."
5. The abandonment of the lakes as source of water supply and the use of deep well water undoubtedly to be found in sufficient abundance for present needs.
6. The opening of a channel to the Illinois River to convey all sewage away from the lake.

The first proposal or the installation of purification plants is obviously not to be considered because of the cost of constructing and maintaining purification plants for a series of independent cities and the greatly increased population that will soon occupy the entire lake front. It is furthermore not practicable to pollute a naturally pure water and then by artificial methods to remove the contaminating material.

The second proposal or the installation of sewage disposal plants is equally unsatisfactory. While it is possible to purify sewage to such an extent that it is not disease-producing, it is not possible so to treat manufacturing wastes that they will not increase the mineral constituents of the water. Moreover, while it is better to drink filtered than raw sewage, both practices are repellant and to be avoided if possible.

The third proposal to stop the dumping of dredged material into the lake is entirely feasible and should at once be carried out. This is also true of the fourth suggestion, which is the abatement of the Glucose sewer.

The fifth suggestion that the lake be abandoned and a water supply sought elsewhere is not tenable. No necessity should be so great as to require the abandonment of one of the largest bodies of potable water in the world and in its place the installation of a deep well system of doubtful adequacy.

The last proposal which is the opening of a channel to the Illinois River is the most feasible and undoubtedly the most practicable. If the necessary Federal and State permission can be secured to allow the carriage of sewage across the line into an adjoining State, it is probable that the engineering problems can be solved. Some such action is the more necessary because the city of South Chicago and the Illinois population now sewering into the Calumet must act with the Indiana cities if the pollution of the lake is to be stopped.

Whatever action is taken either to dispose of sewage or to obtain a pure water supply must be undertaken jointly by all the cities interested. To this end legislation authorizing the establishment of a sanitary district is advisable and is suggested as the first step toward the betterment of civic sanitary conditions of Lake County.

DISCUSSION

Mr. J. H. Brewster: The paper is the result of the findings of a survey made by the State Board of Health of Indiana the past summer for the cities bordering on and taking their water supply from Lake Michigan. The lake county cities have been suffering for the past few years from a heavy typhoid fever death rate; and knowing of the amount of human excreta and trade waste that was entering the lake from the various cities, it was decided to have a survey made of this end of the lake, to find just what the conditions were, and to determine the quality of their present water supply, the probable future quality of it and also to determine the amount and character of the sewage that was going into the lake, and where it was being carried with the different winds and currents.

A Member: I would like to ask what the distance is from the mouth of the glucose sewer to the intake of the Hammond water supply.

Mr. J. H. Brewster: About thirty-five hundred feet.

Prof. J. M. Caird: You reported that a number of times you found the Colon bacillus present at those different points; how large a sample of water did you examine?

Mr. J. H. Brewster: It was one cubic centimeter.

Prof. J. M. Caird: How many tests did you make on each sample?

Mr. J. H. Brewster: Three tests on each sample as far as possible, I was not able to do it on all samples owing to the limited amount of room in my incubator.

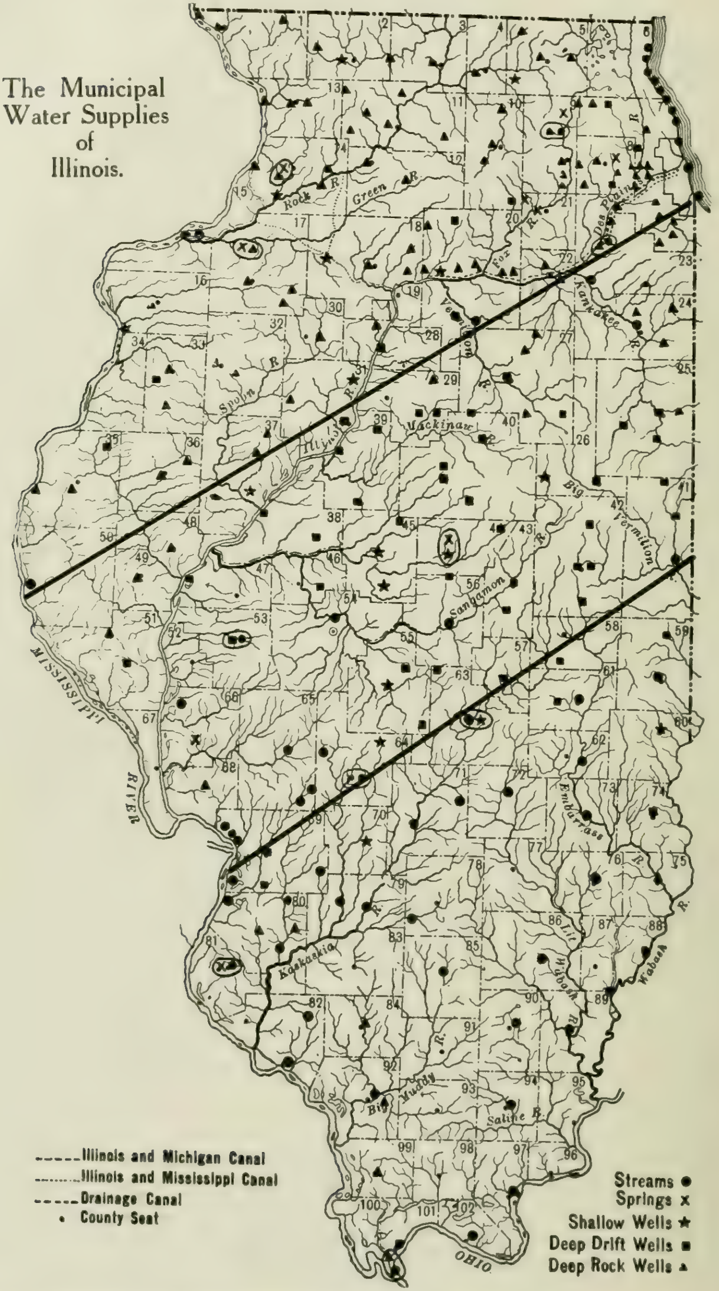
I might state, to show the normal condition of the lake, that one-half mile from the mouth of the harbor at Michigan City, there was absolutely no evidence of Coli or gas forming bacteria.

The culture tubes after having been incubated showed no gas or growth of any kind, the bouillion in every case being perfectly clear.

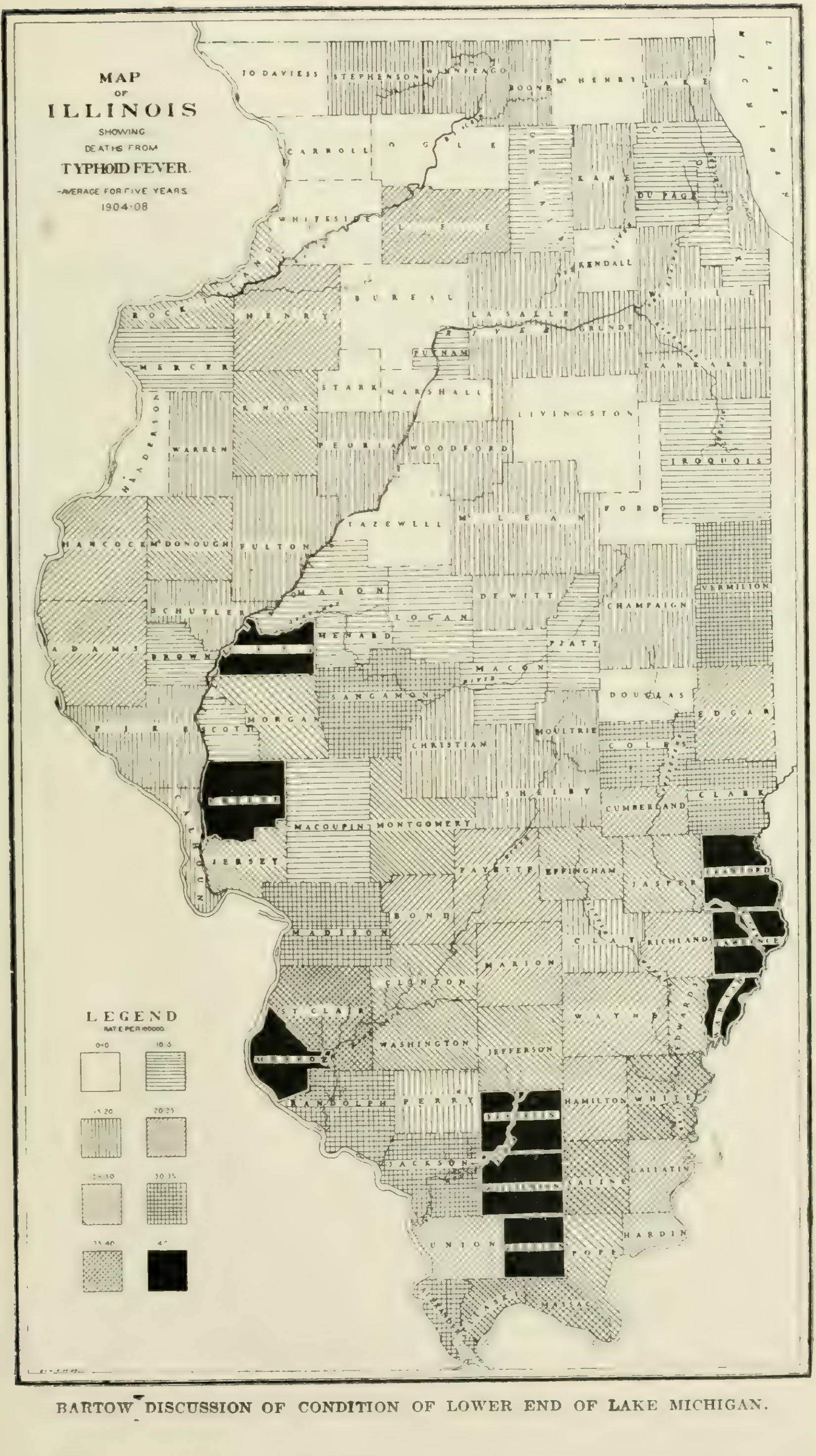
Mr. Edward Bartow: Mr. Brewster has spoken of the need for coöperation between Indiana and Illinois on this subject. It seems in order, therefore, to state that at the time this work was being carried on by the Indiana state board of health, investigations were also being made by the Illinois state water survey along the coast of Illinois north of Chicago. The department of health of Chicago was making investigations of the character of the water from the mouth of Calumet river to the north city limits of Chicago. The report which is about to be printed, as the first report of the Lake Michigan water commission, states that there is a zone of constant pollution extending into the lake one to three miles from the shore, and an intermittent pollution zone varying in width from two to five miles. Along the north shore of Illinois specific surveys have not been made, but examinations of the character of the raw water taken through the intakes of the nine water supplies between Chicago and the Wisconsin line, show that at times all of these supplies are contaminated. The intakes do not go out very far into the lake, so the examination of the water simply shows that the character of the lake along other parts of the shore is the same as along the borders of Chicago; namely, that for a considerable distance from the shore we may expect contamination at some time.

I would like, with your permission, Mr. President, to say a word about the significance of the character of the Lake Michigan water supply with respect to the typhoid fever rate. The typhoid fever rate in the city of Chicago has been decreasing for a number of years. Before they began to take precautions the typhoid fever death rate was one hundred and seventy per one hundred thousand. It has been reduced by extending the intake and by diversion of the sewage from the Chicago river to between fifteen and sixteen per one hundred thousand. Since the typhoid fever rate for well sewered cities in the temperate zone which have unquestioned water supplies should be about seven or eight per one hundred thousand, one cannot but wonder whether the Chicago typhoid rate will be decreased still more. Since it was stated that the typhoid fever rate of the city of Rockford, Illinois, was only seven or eight per one hundred thousand it occurred to me that a study of the distribution of typhoid fever throughout the state might indicate the possibility of a further reduction for Chicago. I obtained statistics from the state board of health covering the last five years, showing the typhoid fever rates in the counties throughout the state. These rates have been averaged and charted, and the accompanying maps show the relation of the water supplies to the typhoid fever rate. Map I shows the character of the water supplies of the state. The state is divided into three parts, according to the water supplies. By drawing a line from Quincy to Lake Michigan we cut off the upper part of the state, in which eighty per cent of the water supplies exclusive of the supplies from Lake Michigan are from deep rock wells. By drawing a line from just below St. Louis to Danville we cut off another part of the state in which the majority of the water supplies are furnished from deep wells which do not enter rock. In the lower part of the state the majority of the water supplies are from streams. The reason that the deep rock wells do not extend below the upper line is because of the amount of mineral matter in such wells in the South. The reason that the drift wells do not extend any further South is because that part of the state in which the drift is 100 ft. deep or more does not extend South of the lowest line.

After determining the typhoid death rates Map II was made. It shows that in the northern two-thirds of the state, a quarter or one-third of the counties have a typhoid fever rate below ten, and only two counties in this part of the state have a rate above



MAP I BARTOW DISCUSSION OF CONDITION OF LOWER END OF LAKE MICHIGAN



BARTOW—DISCUSSION OF CONDITION OF LOWER END OF LAKE MICHIGAN.

forty. There are, I think, only seven counties which have a rate above thirty. In the southern part of the state there are no counties which have a rate below fifteen; there are eight counties with a rate above forty, and eighteen with a rate above thirty.

It would seem that we have a possibility of lowering the typhoid fever rate in Chicago and in the rest of the state, especially in the South, still more. I think that the work which Mr. Brewster has outlined as necessary for Indiana is something which should be carried out in the near future for Illinois and other lake states.

CONCRETE IN WATER WORKS CONSTRUCTION

BY WILLIAM CURTIS MABEE.

The art of concrete construction dates back to ancient times. We learn that the Romans built their important structures of a concrete mixture composed of lime, sand, stone and volcanic dust, and the evidences of their activity in this art are standing today.

The modern art of cement making was not discovered until 1813 and it remained a secret until 1824, when its inventor, Joseph Aspdin, of Leeds, England, procured patents on Portland Cement, so called because of its resemblance to a certain limestone quarried on the island of Portland, England.

His process consisted of combining English chalk with river clay, drying the mixed paste and calcining at high temperatures.

Portland cement was first imported into this country in 1865 and the first Portland cement was manufactured here in 1872.

During recent years the development of the American Portland Cement industry has been nothing short of marvelous, and its use is now almost universal.

This progress has been possible simply because of its merits as a building material.

Portland cement makes an ideal concrete, a perfect artificial stone.

The art of concrete construction has made rapid advances in every branch of engineering and it is especially adapted to water works requirements.

Concrete when properly made is durable, strong, sightly and sanitary and its moderate cost enables it to supplant wood, brick, stone and steel in many instances.

When used in combination with steel for reinforced-concrete work, concrete makes a perfect preservative of the steel; preventing its destruction from corrosion. It will withstand exposure to steam, hot water, wet or dry air, sea-water, sewer and furnace gases without injury to the encased metal. Reinforced-concrete is fire-resisting and practically earthquake proof. The steel supplies the element of tensible strength lacking in the concrete itself.

Concrete has many advantages over other types of construction. It is easily and conveniently handled and transported, often at a less cost than stone masonry, and often suitable sand and gravel for the work in hand can be found on the site. With proper supervision, skilled labor is not essential in the usual work; then again the science of mixing and handling concrete has been so perfected that machines do most of the work.

Concrete has the additional advantage over stone of being molded into intricate shapes. ,

To produce concrete surfaces of a satisfactory smoothness and uniformity it is necessary that the molds be carefully and properly built, and also that the concrete be of the proper consistency to flow readily into the prepared molds, and it is also necessary to thoroughly churn and keep it in motion in the molds until the air has been removed and every crevice filled with mortar. Properly handled in this manner, it will not be necessary to brush or plaster the work after the removal of the forms.

Concrete may be placed in moderately freezing weather if proper precautions are taken to warm the gravel or stone and sand, to heat the water and to cover the work until initial set takes place.

The problem of preventing ugly cracks forming in concrete is one that has worried many engineers. Plain concrete is more than likely to crack where you least expect it, and it has become the practice to provide for these cracks by building short sections in alternate blocks; however, by the judicious introduction of steel bars, objectionable contraction cracks can be entirely eliminated.

The water works engineer or superintendent is particularly interested in the subject of water proofing concrete. It has been shown that wet concrete is more dense and consequently more impervious than dry concrete and that concrete becomes more or less porous as the quantity of cement is increased or diminished. A smoothly trowelled surface produces a water tight film or skin. It has also been found that slaked lime added to the concrete mixture helps to make it less permeable. The lime does not injure the cement in any way, although retarding the setting.

Coal-tar, pitch and asphalt mixtures applied on concrete are used with more or less success. A wash composed of one pound of lye, five pounds of alum and two gallons of water, applied with a brush and well rubbed in, has been used successfully on government fortifications.

A rich cement mortar plastered over concrete makes a very good waterproofing medium.

Proper attention to these details will produce a watertight structure if there is not likely to be contraction cracks, but in works of any magnitude these are bound to occur and can be best provided against by the introduction of steel bars.

A rich concrete, properly reinforced, coated with plaster and trowelled smooth makes an ideal waterproof structure.

Experiments made on large reinforced concrete pipes by the United States Geological Survey, and intended to discharge under pressures up to 35 lb. per square inch, demonstrated the permeability of concrete and the practical value of different kinds of plasters, paints and washes. It was found that all of the tests made on washes or paints gave poor results.

The conclusion drawn from these experiments was that the best results could be obtained by giving the inside of the pipe one coat of plaster one-half inch thick, composed of one part cement to one and one-half parts sand and a small quantity of lime paste thoroughly cooled to retard setting, keeping the pipe well wet ahead of the plastering, and when this coat which is left rough had dried, add another coat about one-quarter inch thick of plaster composed of one part cement to one part of sand. This coat should be trowelled to a smooth surface and when dry the entire inside surface of the pipe should be covered with a thick wash of cement and water.

When the water pressures are not great and the concrete is sufficiently rich in cement, no plastering is necessary.

Concrete has found a wide field of usefulness in its application to water works, and indeed it would be extremely difficult to imagine a purification works built today in which concrete was not the principal building material, from the foundations to the superstructure. It is particularly adapted to the construction of water conduits and pipe lines, to tanks and basins, to water towers and standpipes, to reservoirs and clear wells and to filters, either slow or mechanical.

Indeed the present day mechanical filters have been considerably modified by the adoption of concrete construction. The rectangular shape of the concrete mechanical filter is rapidly replacing the circular wooden or steel tank, as its use results in an economy of space.

Little Falls, New Jersey, was the first plant to adopt the rectangular tank and the general use of concrete throughout its purification system. This plant was built in 1901.

Engineer Wm. Wheeler in 1885 built the first filters in this country having groined arch covering, at Ashland, Wisconsin.

He used brick piers and brick arches, backed with concrete, and in 1896 built two filters at Somersworth, New Hampshire, with granite piers and brick arches backed with concrete.

In 1897 Freeman C. Coffin built a reservoir at Wellesley, Mass., having brick piers and all concrete arches.

Charles Hermany in 1900, at Louisville, Ky., built his clear water reservoir with groined arch vaulting of "concrete-metal," and the piers of concrete 3.4 ft. in diameter, having a span of 22 ft. center to center of supports and a rise of 3.8 ft. The columns were 21 ft. high, and made of Portland Cement concrete.

About this same time John W. Hill at Philadelphia began the construction of its immense filtration system, using concrete exclusively for the filters.

The use of the concrete groined arch covering for reservoirs and filters is now quite general.

New Haven, Conn., under the direction of George W. Fuller in 1904, was the first to depart from the groined arch type of cover for its filtration plant, adopting the reinforced concrete flat slab and beam construction with reinforced concrete columns.

It has been the writer's privilege to be connected with the Indianapolis Water Company in the development of its purification system, involving pretty generally the use of concrete, and the following descriptions and illustrations of these works are submitted for your consideration, together with the several items of cost which are usually interesting to those of you who are engaged in this kind of work.

REINFORCED-CONCRETE AQUEDUCT

The filter plant is supplied by a gravity flow from the Indiana State Central Canal, which was originally built by the State for transportation purposes and later was purchased from the state by the Company.

The head gates and concrete sluice-ways of this canal are located about six and one-half miles above the intake to the filters.

The canal is carried over Fall Creek near the Filter Plant in an open aqueduct at a height of eighteen feet above said creek.

On March 26, 1904, a disastrous flood carried away the existing aqueduct which was built of wood, supported by steel trusses on rubble masonry piers and abutments. View No. 1 shows this structure during the flood with the water from the canal escaping into the creek behind the stone abutment. The middle pier was undermined and scoured out, crumbling and breaking up the superstructure. View No. 2 shows the condition of this pier and abutment after the flood had subsided.

The aqueduct as rebuilt is shown on View No. 3. The details of construction and concrete handling system on View No. 4.

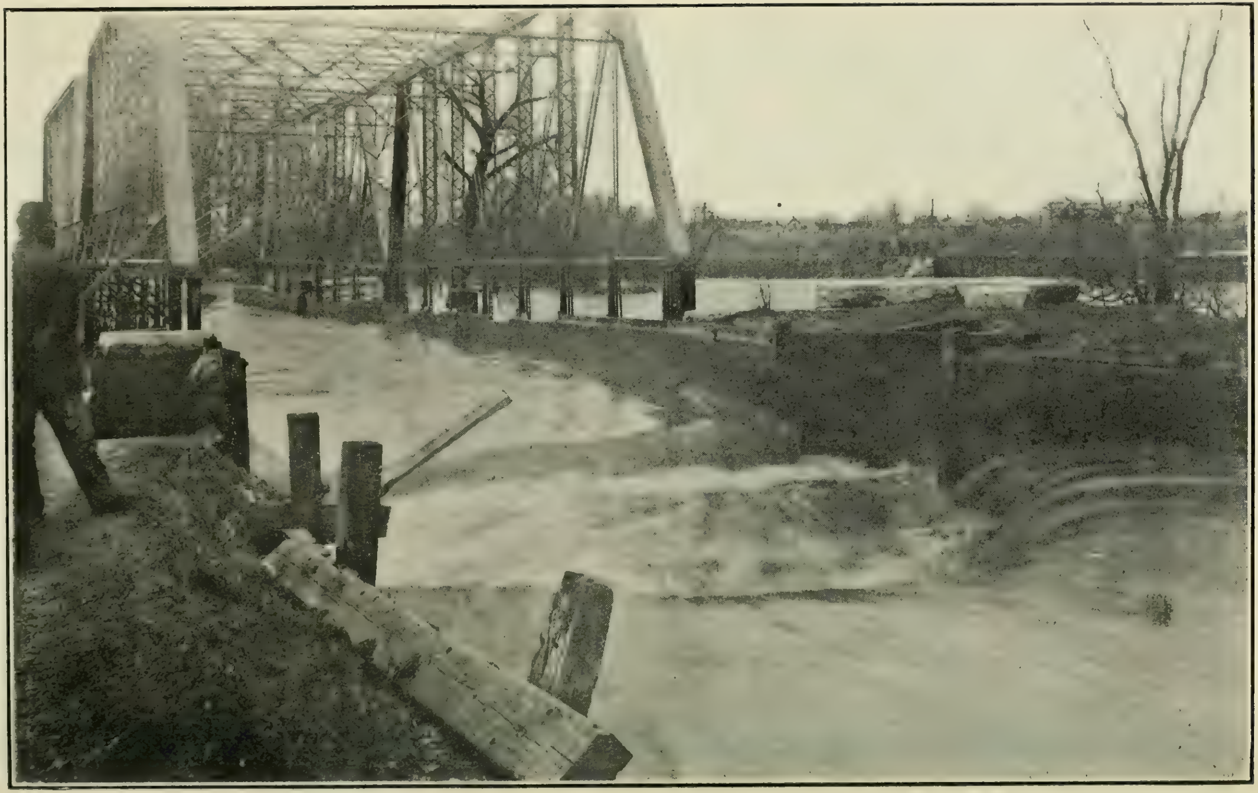
The aqueduct is a reinforced concrete structure 300 ft. long and 41 ft. wide, having four skew segmental arches, each of 60 ft. span with a 10-ft. rise from the springing line to the soffit, and a crown thickness of 18 in. The height from the foundation courses to the tow path is 35 ft. 9 in.

The foundations for the piers, abutments and wing walls were carried down 16 ft. below low water and rested upon a bed of sand and gravel.

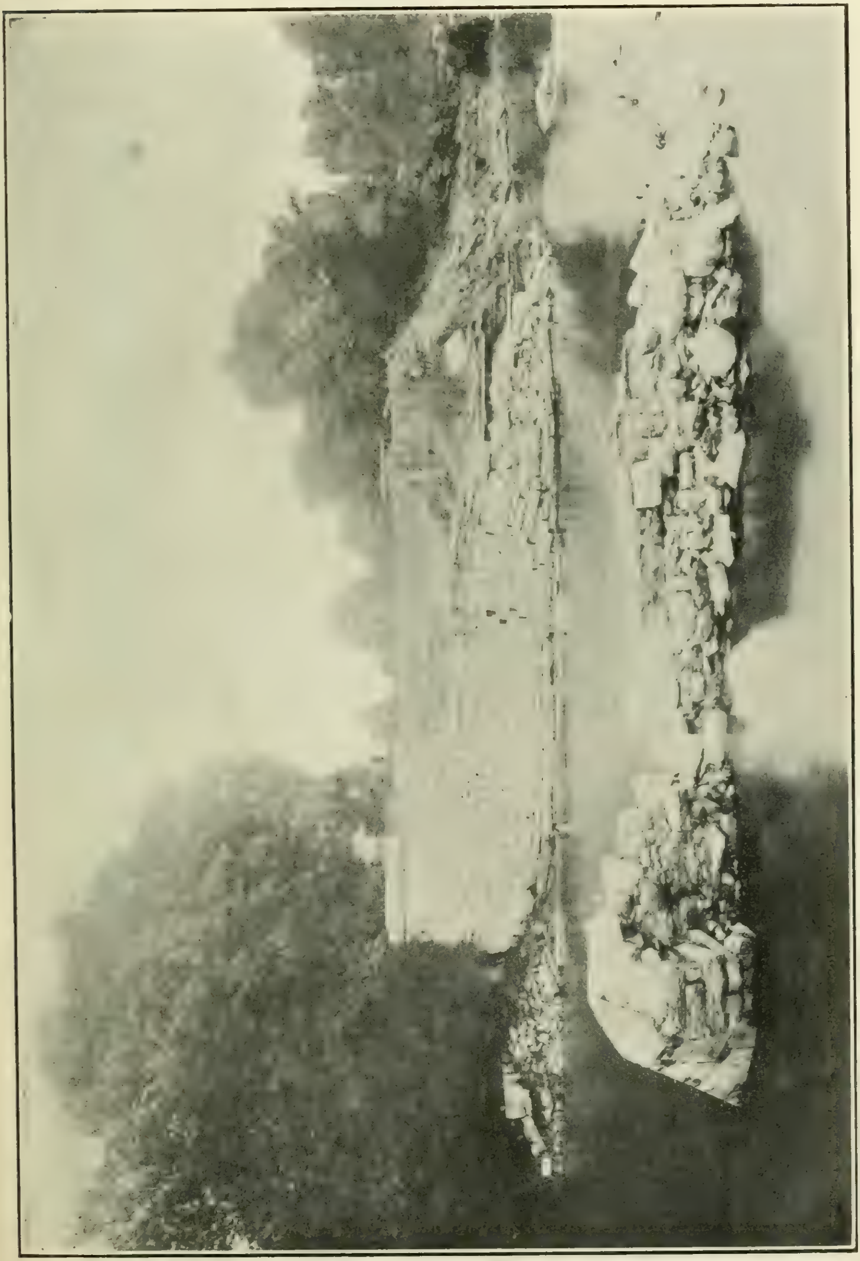
The arch ring is reinforced with 8 in. steel I-beams spaced 2 ft. 6 in. on centers and bent to the curvature of the arch.

Over the extrados of the main arches and in line with Fall Creek was built small transverse arches, the purpose of which was to increase the discharging capacity of the bridge during freshets and to eliminate the possibility of freezing, which might occur with hollow spandrels.

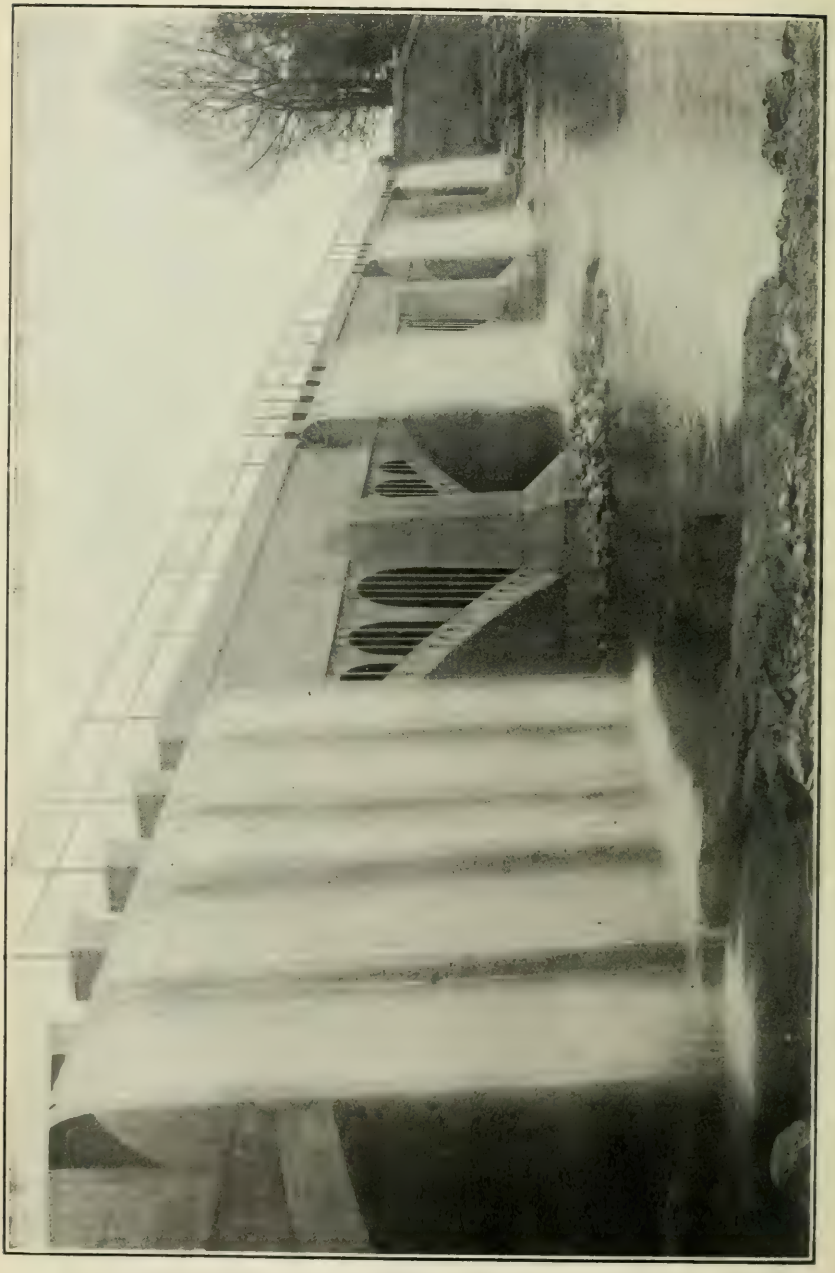
Over these smaller arches was placed the trunk or aqueduct proper; this was constructed of a 9-in. concrete slab reinforced with steel rods, extending into the side walls, which were 6 ft.



VIEW 1. DESTRUCTION OF AQUEDUCT BY FRESHET, MARCH 26, 1904

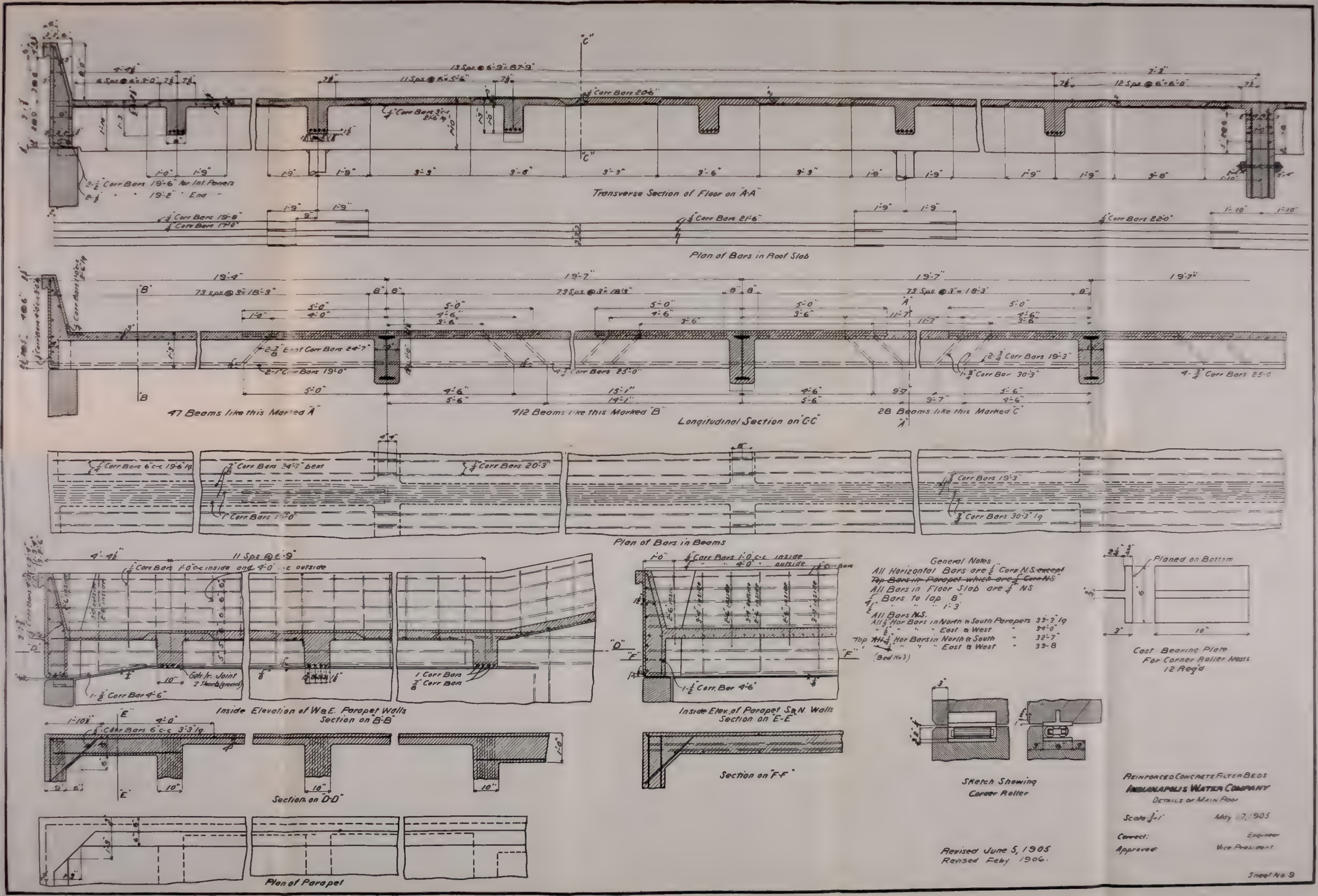


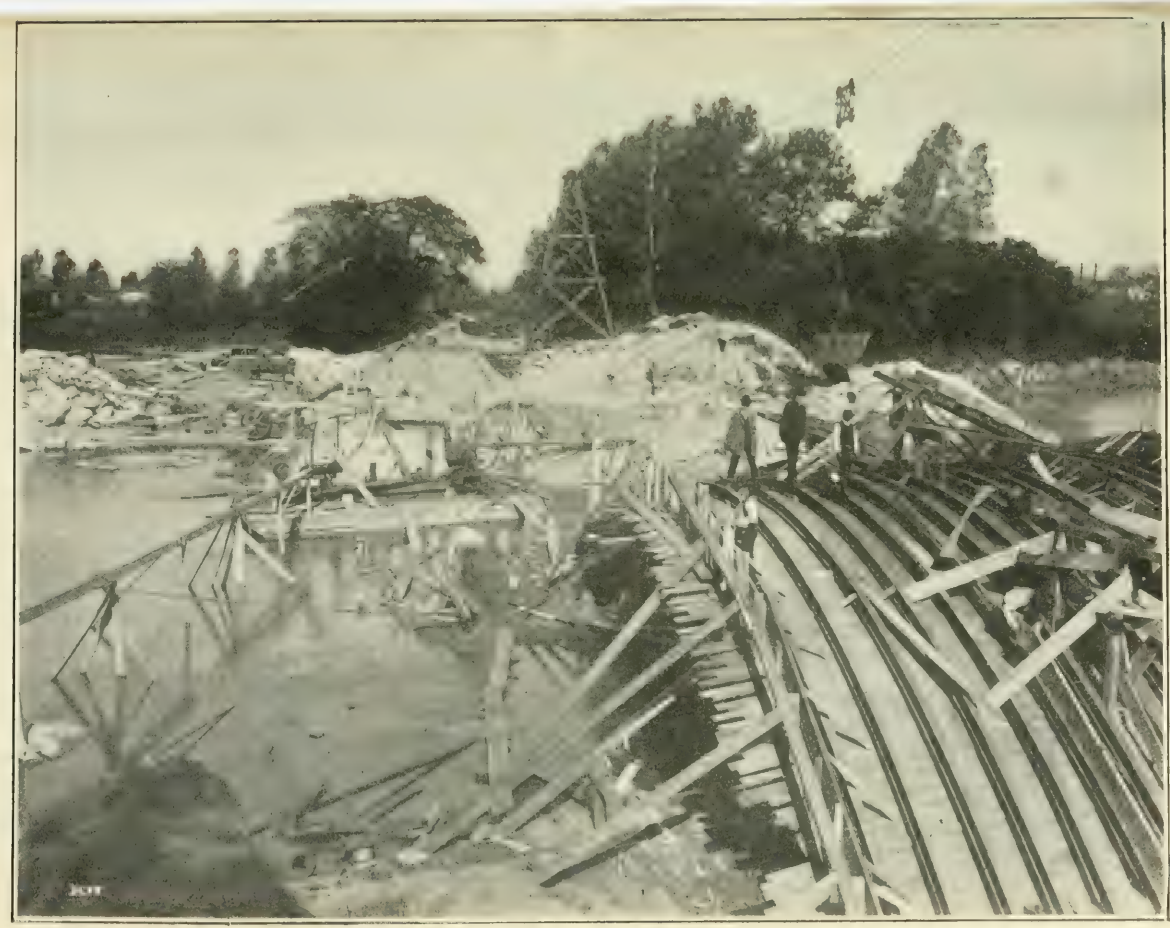
VIEW 2. FAILURE OF RUBBLE MASONRY AT AQUEDUCT



VIEW 3. CONCRETE AQUEDUCT. REPLACING STEEL TRUSSES ON RUBBLE MASONRY PIERS

FIGURE 1.


"C"
"C"
13 Spa @ 6'-9" = 87'-9"
11 Spa @ 6' = 5'-6"
12 Spa @ 6'-6"
2'-2 1/2" Corr Bars 19'-6" for Int. Panels
2'-1/2" " " 19'-2" End "
Transverse Section of Floor on "A-A"
1/4" Corr Bars 19'-8"
1/4" Corr Bars 17'-0"
1/4" Corr Bars 21'-6"
1/4" Corr Bars 22'-0"
Plan of Bars in Roof Slab
19'-4"
19'-7"
19'-7"
19'-7"
"B"
"B"
"A"
"A"
73 Spa @ 3" = 18'-3"
4-2 7/8" Bent Corr Bars 24'-7"
2-1" Corr Bars 19'-0"
1/4" Corr Bars 25'-0"
2-3/4" Corr Bars 19'-3"
1-3/4" Corr Bar 30'-3"
4-3/4" Corr Bars 25'-0
47 Beams like this Marked "A"
412 Beams like this Marked "B"
Longitudinal Section on "C-C"
28 Beams like this Marked "C"
1/4" Corr Bars 6" c-c 19'-6" lg
7/8" Corr Bars 24'-7" bent
1/4" Corr Bars 20'-3"
1" Corr Bars 19'-0"
3/4" Corr Bars 19'-3"
3/4" Corr Bars 30'-3" lg
Plan of Bars in Beams
11 Sps @ 6'-9"
1/2" Corr Bars 1'-0" c-c inside and 4'-0" c-c outside
Galv. Ir. Joint 2 Sheets (ground)
1-1/2" Corr Bar 4'-6"
1 Corr Bars
7/8" Corr Bars
"D"
"D"
"F"
"F"
Inside Elevation of W.& E. Parapet Walls
Section on "B-B"
1/4" Corr Bars 1'-0" c-c inside
" " 4'-0" " outside
1-1/2" Corr. Bar 4'-6"
Inside Elev. of Parapet S.& N. Walls
Section on "E-E"
General Notes
All Horizontal Bars are 1/2" Corr N.S. ~~except~~
~~Top Bars in Parapet which are 1/4" Corr N.S.~~
All Bars in Floor Slab are 1/4" N.S.
1/4" Bars to lap 8"
1/2" " " " 1'-3"
All Bars N.S.
All 1/2" Hor Bars in North & South Parapets 33'-3" lg
" 1/2" " " " East & West " 34'-0"
Top ~~All~~ 1/4" Hor Bars in North & South " 32'-7"
" 1/4" " " " East & West " 33-8
(Bed No 3)
Planed on Bottom
Cast Bearing Plate For Corner Roller Nests 12 Req'd
"E"
"E"
1/4" Corr Bars 6" c-c 3'-3" lg.
Section on "D-D"
Section on "F-F"
Sketch Showing Corner Roller
Plan of Parapet
Revised June 5, 1905
Revised Feby 1906.
Reinforced Concrete Filter Beds
Indianapolis Water Company
Details of Main Roof
Scale 3/4" = 1'
May 7, 1905
Correct: Engineer
Approved: Vice President
Sheet No. 9



VIEW 4. CONCRETE AQUEDUCT. CONSTRUCTION VIEW OF AQUEDUCT SHOWING I-BEAMS

high and 2 ft. 6 in. wide with a projection of 2½ ft. supported by concrete brackets, making a walk or tow path 5 ft. wide on the down stream and a series of notches or weirs on the upstream side to relieve the canal of surplus water.

The trunk is 36 ft. wide in the clear, with a depth of water in the channel of 5 ft. These side walls were built in short alternate sections and were connected by sheet-lead expansion joints. The lead sheet was about 20 in. wide and 6 ft. long; it was folded lengthwise with a convolution in the center of the sheet and holes were punched in the sheet for anchorage in the adjoining sections.

This expedient has proved entirely successful. the aqueduct having been in service now for four years and no leaks have ever developed in the trunk, although contractions of the sections are evident during cold weather. This work was done during the winter of 1904-5.

The structure contains 4500 cu. yds. of concrete mixed 1-2-4, the unit cost being as follows:

Per Cubic Yard of Concrete

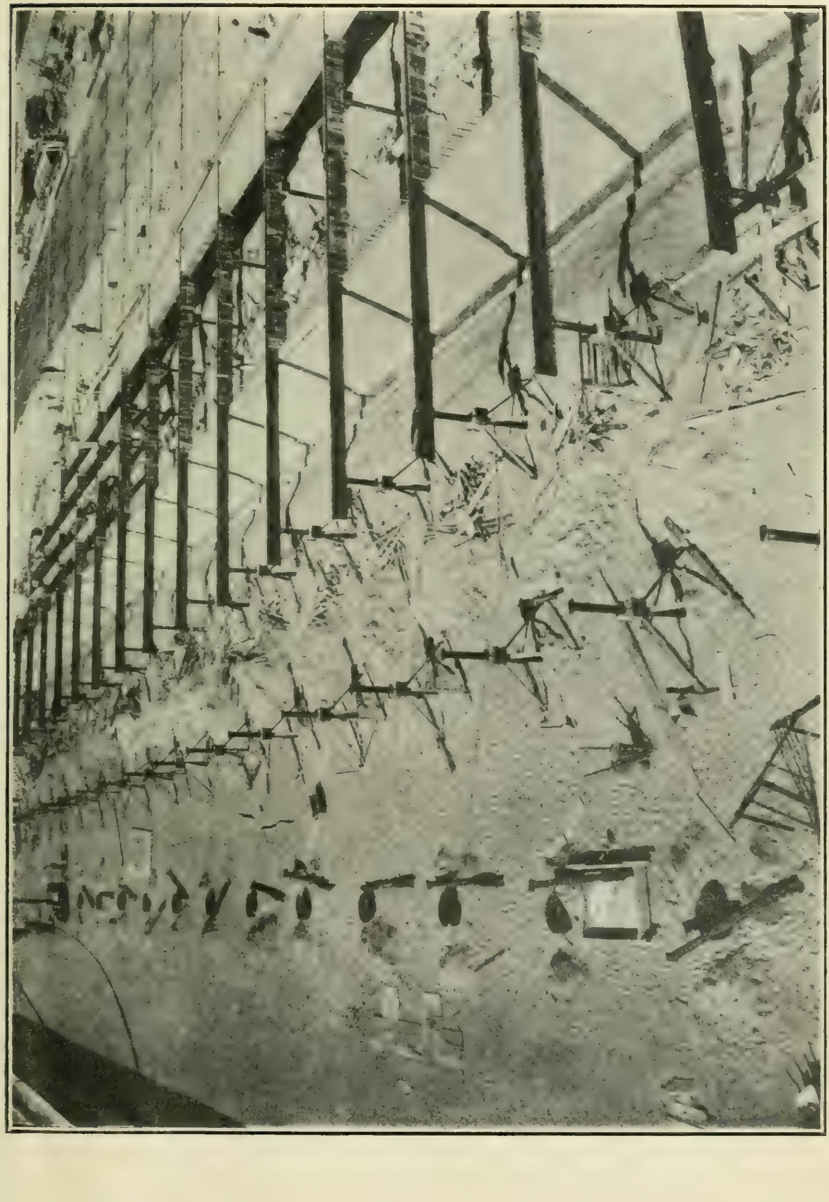
Cement	$1.90
Steel	.77
Sand and gravel	.54
Lumber	.90
Form Labor	1.12
Concrete labor	1.29
	$6.52

REINFORCED CONCRETE-FILTER COVERS

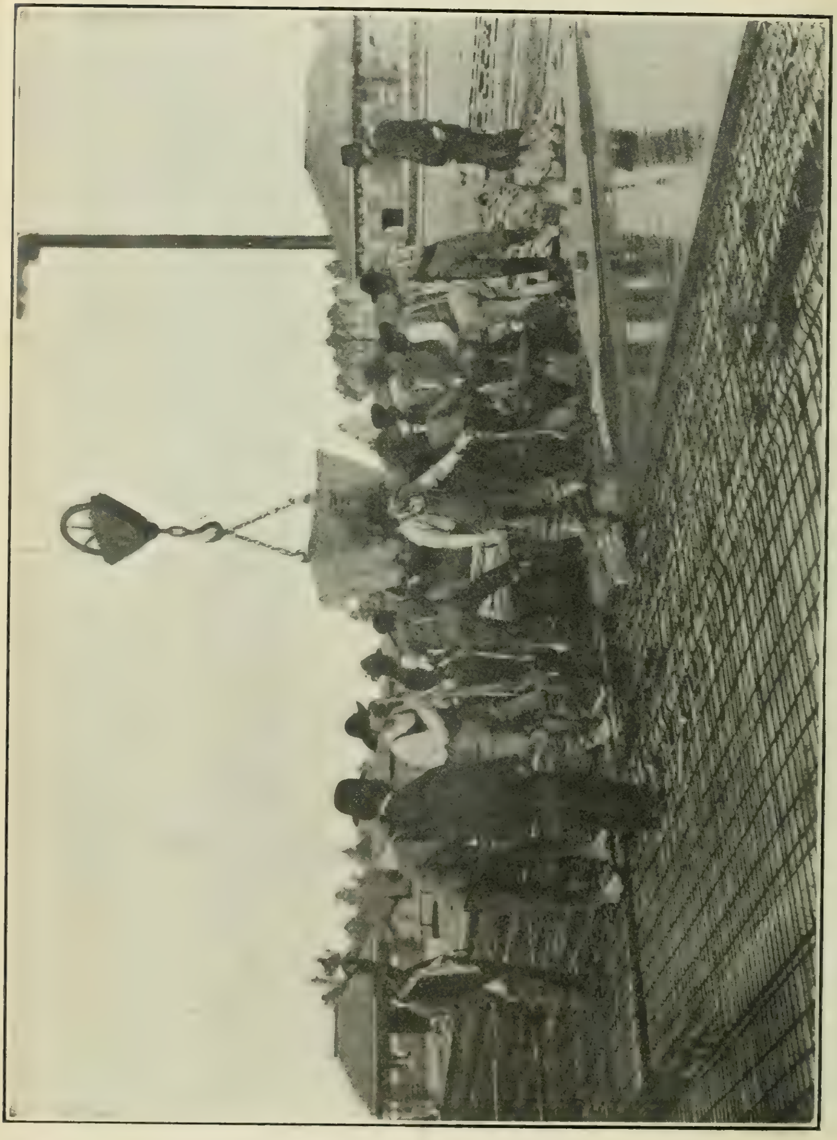
The filters built in 1902 are of the slow sand type, covering 4.8 acres; they were originally built open and in three large units.

It was found necessary to cover and divide them into six units, approximately 100 x 350 ft. each. Figure No. 1 shows the plan adopted for this covering. View No. 5 shows the work in progress of construction. View No. 6 shows the method of placing concrete and View No. 7 shows the concrete mixing station. View No. 8 shows the interior of the completed filter, with men scraping the sand surface.

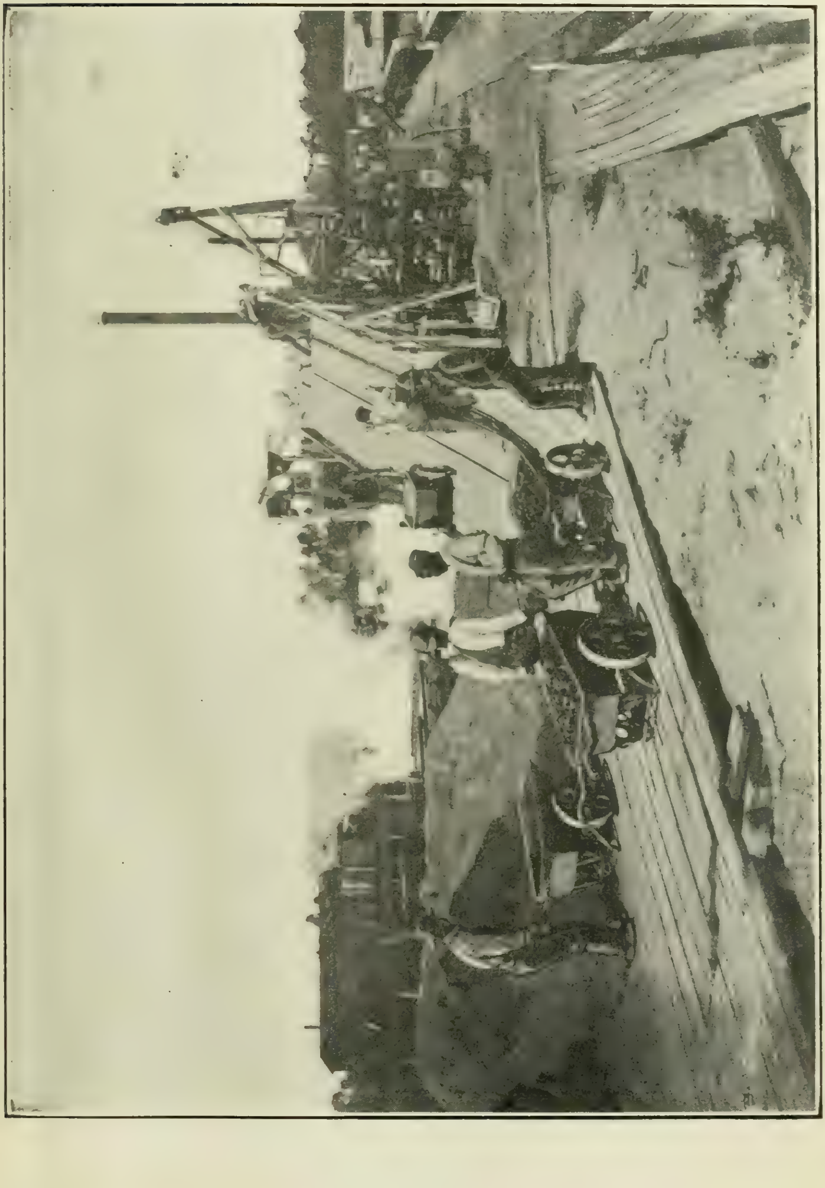
Cast-iron columns were selected for the supports in preference to concrete piers, to save time in the erection of the same and to



VIEW 5 FILTER COVERS. THIS VIEW SHOWS THE METHOD OF CONSTRUCTION OF THE COVERS AND DIVIDING WALLS, AND ILLUSTRATES THE RAPIDITY WITH WHICH THE COLUMNS AND BEAMS COULD BE ERECTED



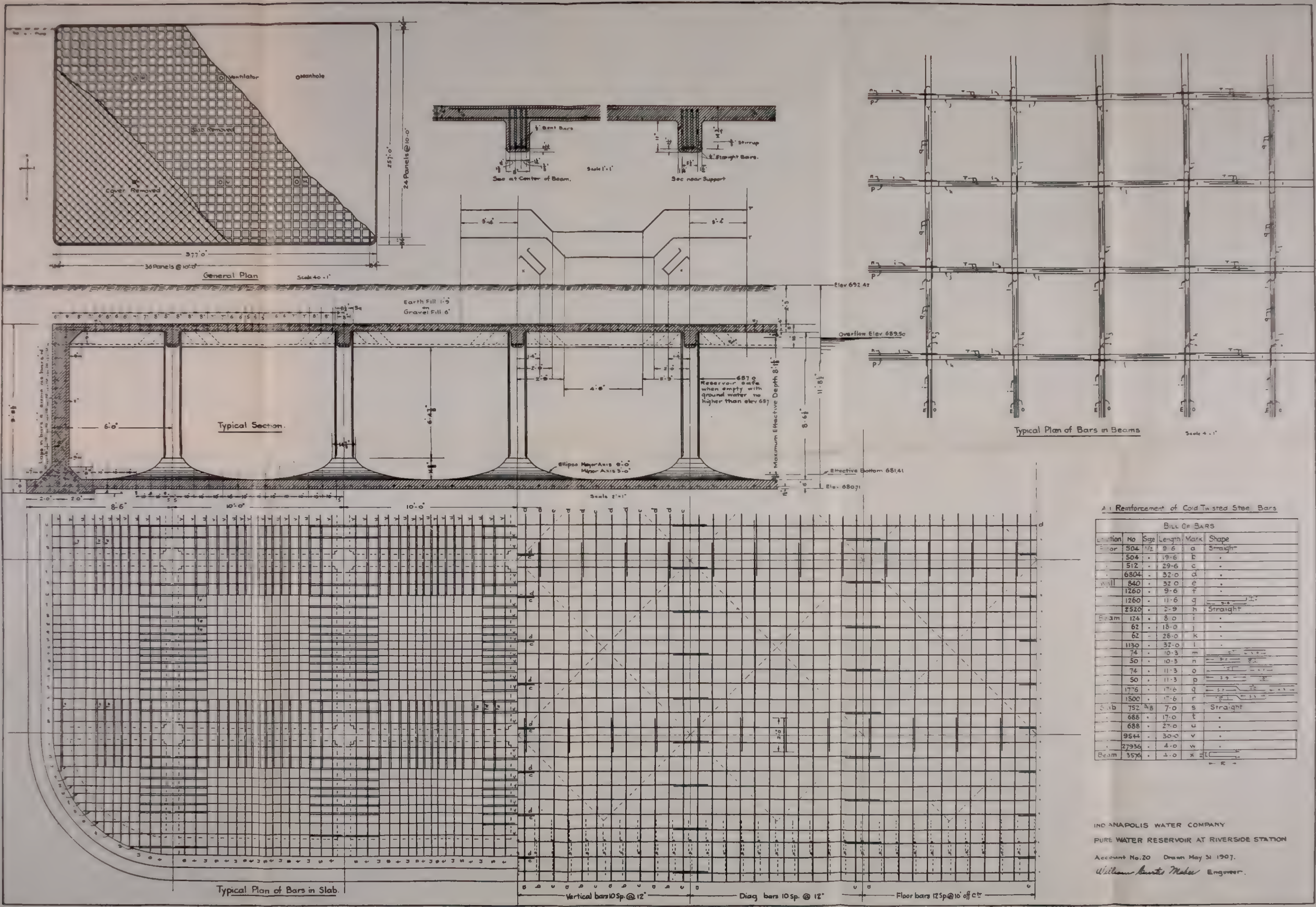
VIEW 6. FILTER COVERS. PLACING CONCRETE ON COVER OF FILTER; DUMPING FROM CABLE-BUCKET INTO BOX AND SPREADING WITH SHOVELS



VIEW 7. FILTER COVERS. METHOD OF HANDLING GRAVEL AT CENTRAL MIXING STATION. AN ENDLESS CHAIN CARRIES THE LOADED BARROWS UP THE INCLINE

VIEW 8. FILTER COVERS. INTERIOR OF COMPLETED FILTERS DURING A CLEANING PERIOD

FIGURE 2.



All Reinforcement of Cold Twisted Steel Bars

BILL OF BARS					
Location	No	Size	Length	Mark	Shape
Floor	504	½	9-6	a	Straight
	504	.	19-6	b	.
.	512	.	29-6	c	.
.	6804	.	32-0	d	.
Wall	840	.	32-0	e	.
	1260	.	9-6	f	.
	1260	.	11-6	g	
	2520	.	2-9	h	Straight
Beam	124	.	8-0	i	.
	62	.	18-0	j	.
	62	.	28-0	k	.
	1130	.	32-0	l	.
	74	.	10-3	m	
	50	.	10-3	n	
	74	.	11-3	o	
.	50	.	11-3	p	
.	1776	.	17-6	q	
	1800	.	17-6	r	
Slab	752	⅜	7-0	s	Straight
.	688	.	17-0	t	.
	688	.	27-0	u	.
	9544	.	30-0	v	.
.	27936	.	4-0	w	.
Beam	3576	.	4-0	x	

INDIANAPOLIS WATER COMPANY

PURE WATER RESERVOIR AT RIVERSIDE STATION

Account No. 20 Drawn May 31 1907.

William Curtis Mabee Engineer.

minimize the disturbance of the filter material and pure water drainage system, which had been completed and in operation since September, 1904. No provision had been made for covers in the original plans.

The covers consist of 3-in. slabs supported by concrete beams 19 ft. 7 in. long spaced 6 ft. 9 in. on centers; the beams being 8 in. wide and 15 in. deep; these beams are in turn carried by 18-in. I-beams encased in concrete and bolted to the columns, forming a continuous girder 22 in. deep, which is supported on cast-iron columns 7 in. in diameter and spaced 20 ft. 3 in. on centers.

The columns rest on cast-iron base plates 15 in. square, laid on short piers.

These columns are filled with concrete and are kept painted outside with asphalt paint.

The excavations for the columns was accomplished by means of cylindrical sections of steel plate which were easily driven down through the four feet of filtering material.

The partition walls are each 350 ft. long, 14 to 17 ft. high and 1 ft. thick, reinforced in both faces vertically and longitudinally with ¾ and ½-in. bars respectively. The slab reinforcing is ¼-in. bars spaced 3 in. on centers in the direction of load and 6 in. on centers in the opposite direction.

The beams are continuous over nineteen supports and the girders over eleven supports.

The entire slab, covering 70,000 sq. ft. in each double filter, is built monolithic, without any attempt to provide expansion joints.

About the four sides there is a parapet wall for retaining a cinder filling, and for closing the spaces between the beams. This wall is kept separate from the main supporting wall by a paraffine joint, the I-beams resting on rollers in the wall. The lubricated joint was provided to allow the cover to expand and contract freely without introducing bending into the main wall. These covers and walls are water tight for all practical purposes.

In the removal of forms, from ten days to two weeks were allowed to elapse after placing the concrete.

The work was done with a cable tramway spanning 450 ft., suspended from movable towers mounted on tracks, the concrete being handled from the mixer to the cable way by means of a shuttle car on a narrow gauge track, propelled by a stationary engine and cable. In this way 80 cu. yds. was an average day's work covering 5000 sq. ft. of surface.

Cost of Covers

	Per cu. yd.	Per sq. ft.
Reinforcing bars	4.45	0.076
Labor placing bars	0.65	0.011
I-beams	......	0.063
Placing I-beams	......	0.003
Sand and gravel	0.75	0.01
Cement	1.85	0.031
Placing concrete	1.06	0.018
Lumber for forms	1.06	0.018
Labor on forms	3.52	0.060
Columns	......	0.031
Miscellaneous material and labor	1.31	0.020
	$14.65	$0.344

Superintendence not included. The concrete was mixed 1: 2: 4.

Cost of Walls

	Per cu. yd.	Per cu. ft.
Reinforcing bars	3.05	0.113
Placing bars	0.76	0.028
Sand and gravel	0.75	0.028
Cement	1.61	0.060
Placing concrete	1.00	0.037
Lumber for forms	0.55	0.020
Labor on forms	2.98	0.110
Miscellaneous	1.36	0.051
	$12.06	$0.447

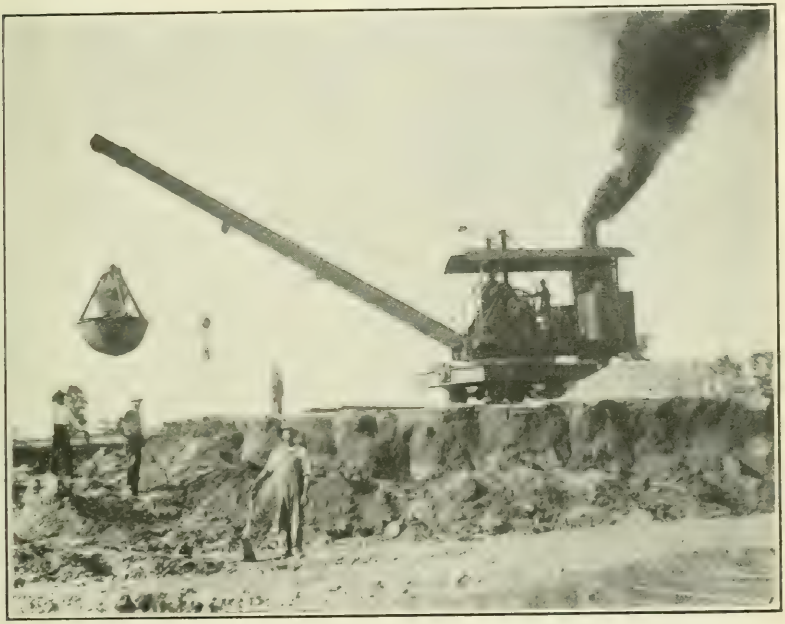
PURE WATER RESERVOIR

Figure No. 2 shows the design of the 5,500,000 gallon pure water reservoir built during the season of 1907, and is illustrated by Views Nos. 9–16.

The reservoir is built near Fall Creek on a gravel foundation at the ordinary ground water level. The groined arch bottom was designed to resist the upward thrust of extraordinary high ground water at such times as the reservoir is empty.

The earth fill, 2 ft. deep on the cover, and the weight of the structure itself would overbalance any upward pressure that might occur. The inverted groined arch construction also distributes this load uniformly over the bottom.

The lower section of the arch is reinforced with ½-in. twisted bars spaced 10 in. on centers in either direction, to bond the sections together and to prevent contraction cracks. The joints were brushed with cement grout in addition.



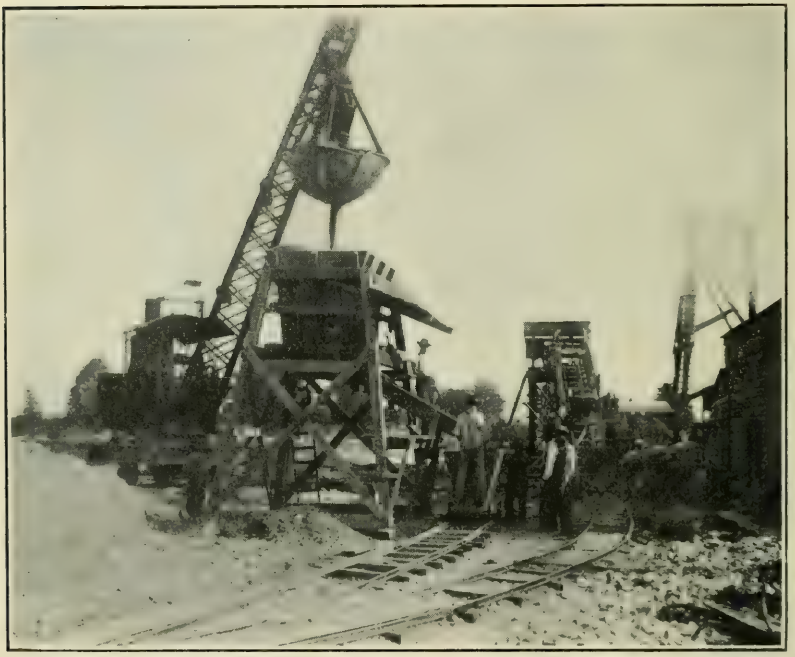
VIEW 9. PURE WATER RESERVOIR. VIEW SHOWING EXCAVATING MACHINE USED IN CONNECTION WITH LOCOMOTIVE AND CARS CARS FOR EXCAVATING THE TOP SOIL

No other water roofing material was used, as under the low head of water carried, the amount of percolation through the concrete itself would be inconsiderable if cracks could be prevented.

The walls were 1 ft. thick, securely anchored to the floor and cover, and were reinforced against side thrust in both faces and against longitudinal temperature stresses by bars as shown. The wall was built monolithic about the four sides of the reservoir, the corners being rounded by curves.

Nothing worse than a few fine hair cracks showed up and these did not occur at the corners as is usually the case.

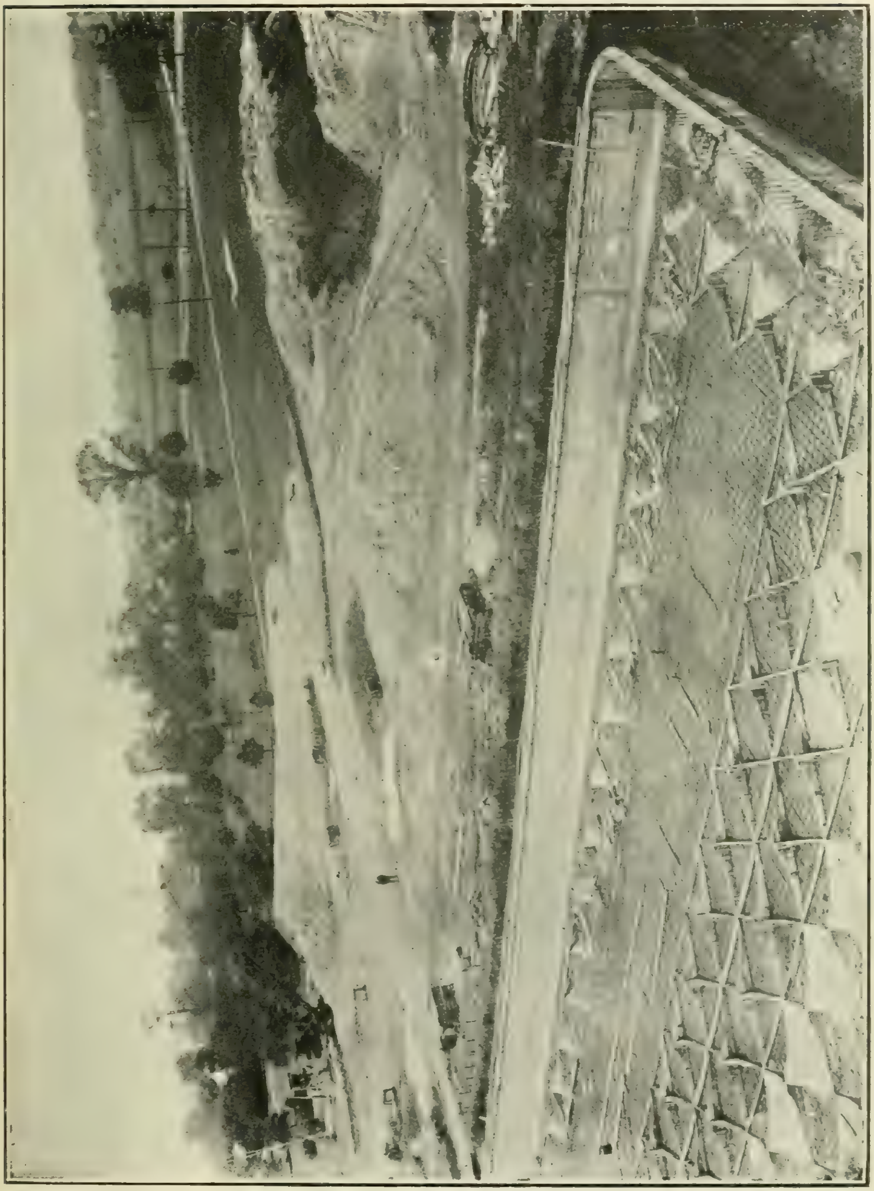
The roof slab is 5 in. thick, reinforced with ⅜-in. rods as shown, with variable spacing; this slab is supported by concrete beams 8 in. wide and 16 in. deep, which are carried by plain concrete columns 12 in. sq., spaced 10 ft. on centers.



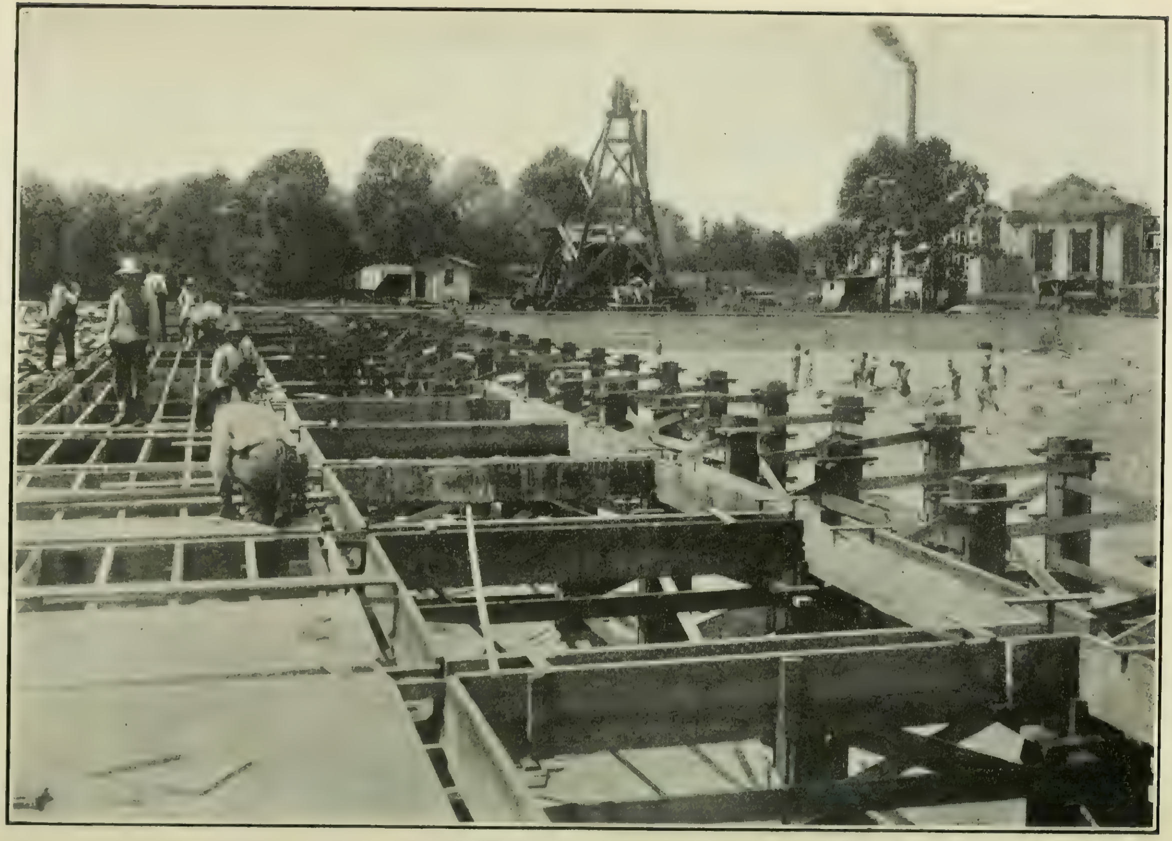
VIEW 10 PURE WATER RESERVOIR. LOADING STATION FOR GRAVEL AND CEMENT, SHOWING INCLINED TRACK AND SWITCH

The costs as follows do not include superintendence or office expenses.

Cost per 1000 gallons stored—$9.33	Per sq. ft. of water surfaces
Excavation (7 feet cut)	0.08¼
Refill on cover (2 feet)	0.03
Floor	0.15¼
Wall (distributed)	0.04½
Cover	0.24½
	$0.55½

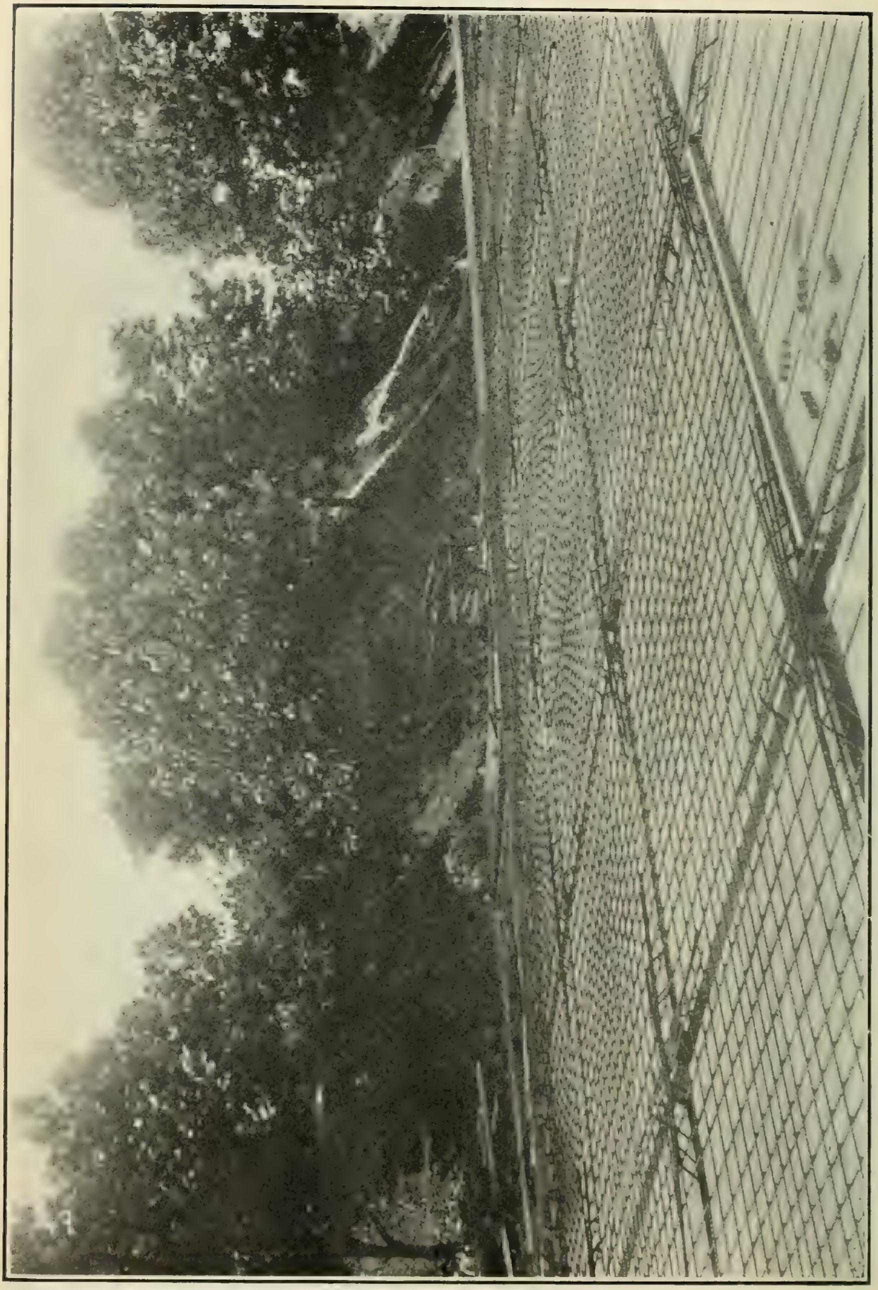


VIEW 11. PURE WATER RESERVOIR. VIEW TAKEN FROM TOP OF CABLE-TOWER SHOWING GROINED ARCH, FLOOR AND WALL; ALSO GRAVEL BANK AND SPOIL BANK IN DISTANCE

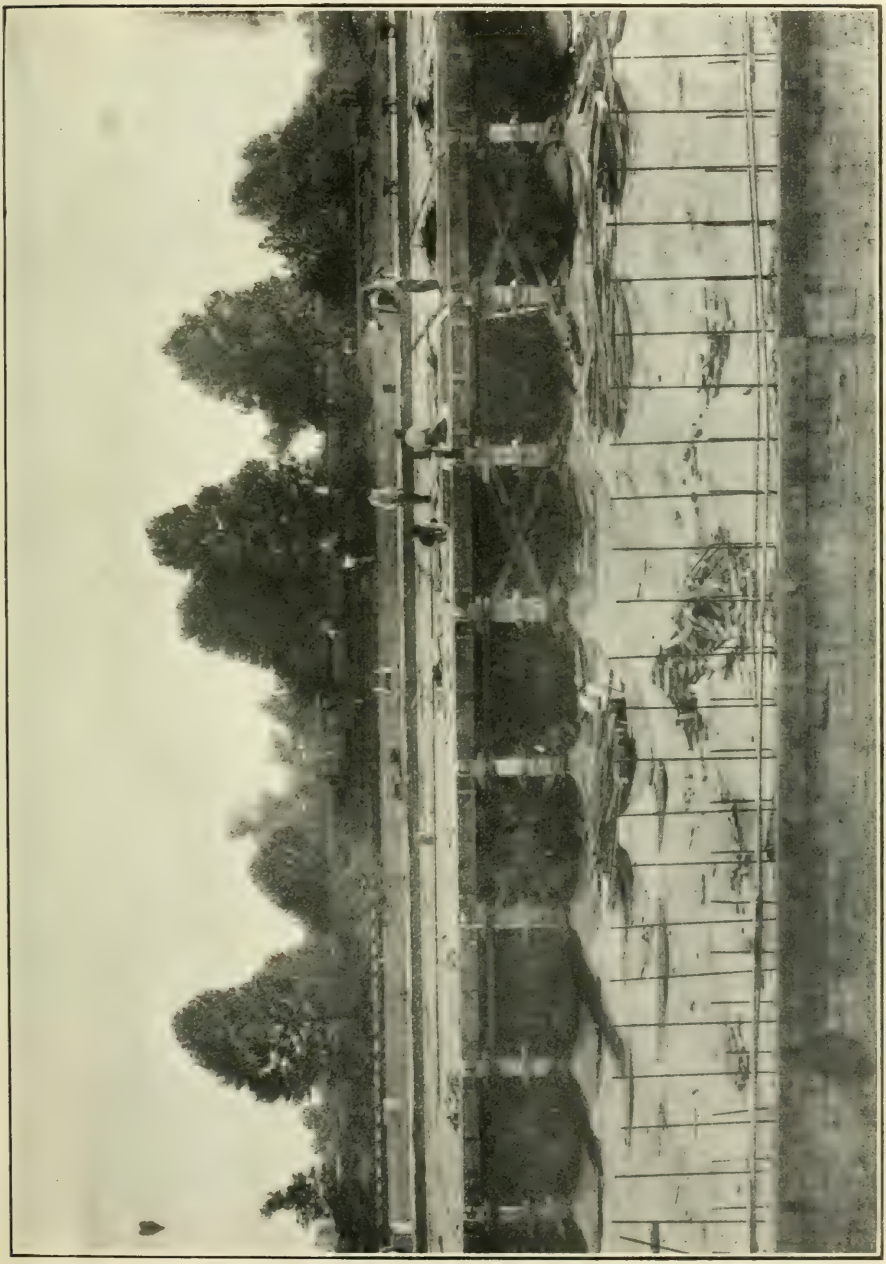


VIEW 12. PURE WATER RESERVOIR. FORM WORK

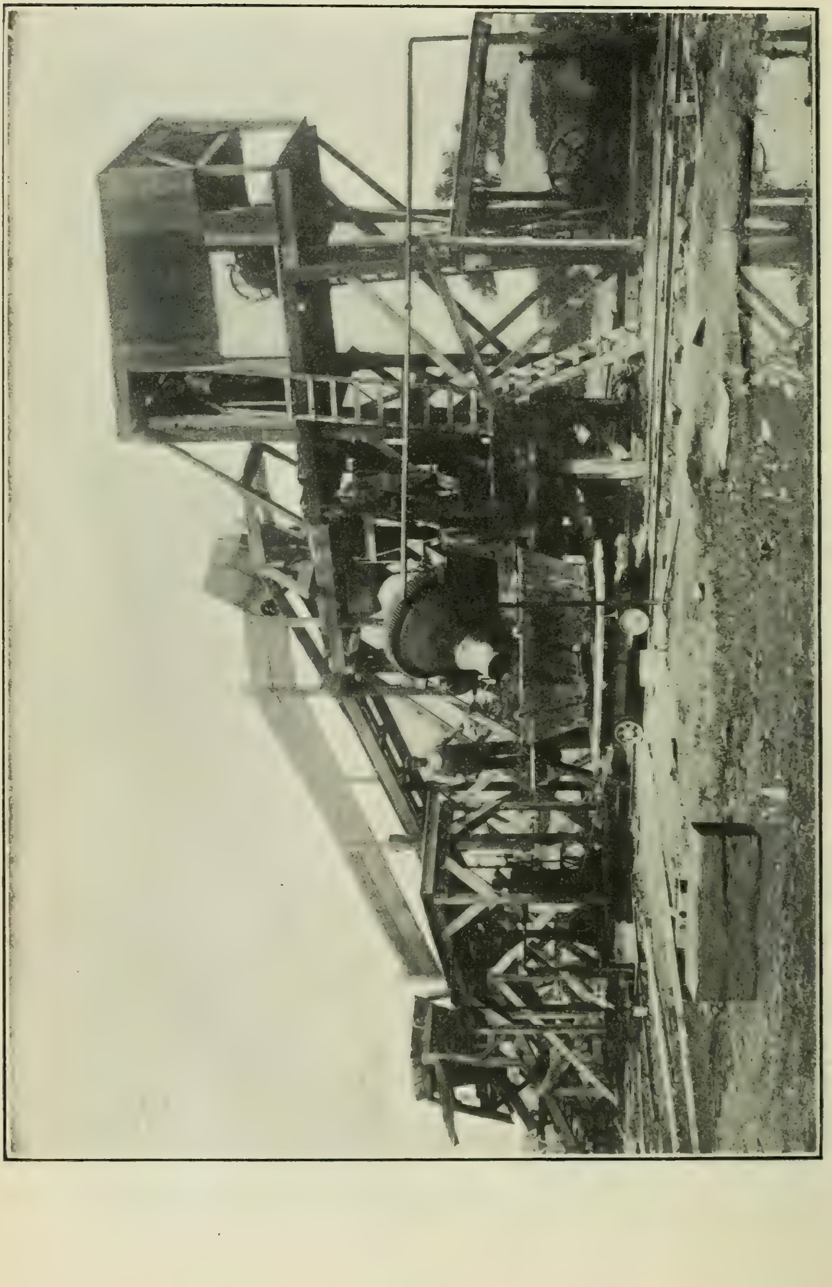
VIEW 13. PURE WATER RESERVOIR. MAKING USE OF THE CABLE-WAY IN DISTRIBUTING THE FILL ON COVER



VIEW 14. PURE WATER RESERVOIR. REINFORCING BARS IN POSITION READY FOR COVER SLAB. NOTICE CONCENTRATION OF METAL ON CENTER OF SLAB AND BENT BARS IN BEAMS. ALSO CEMENT BRIQUETTES FOR HOLDING AND SPACING BEAM RODS

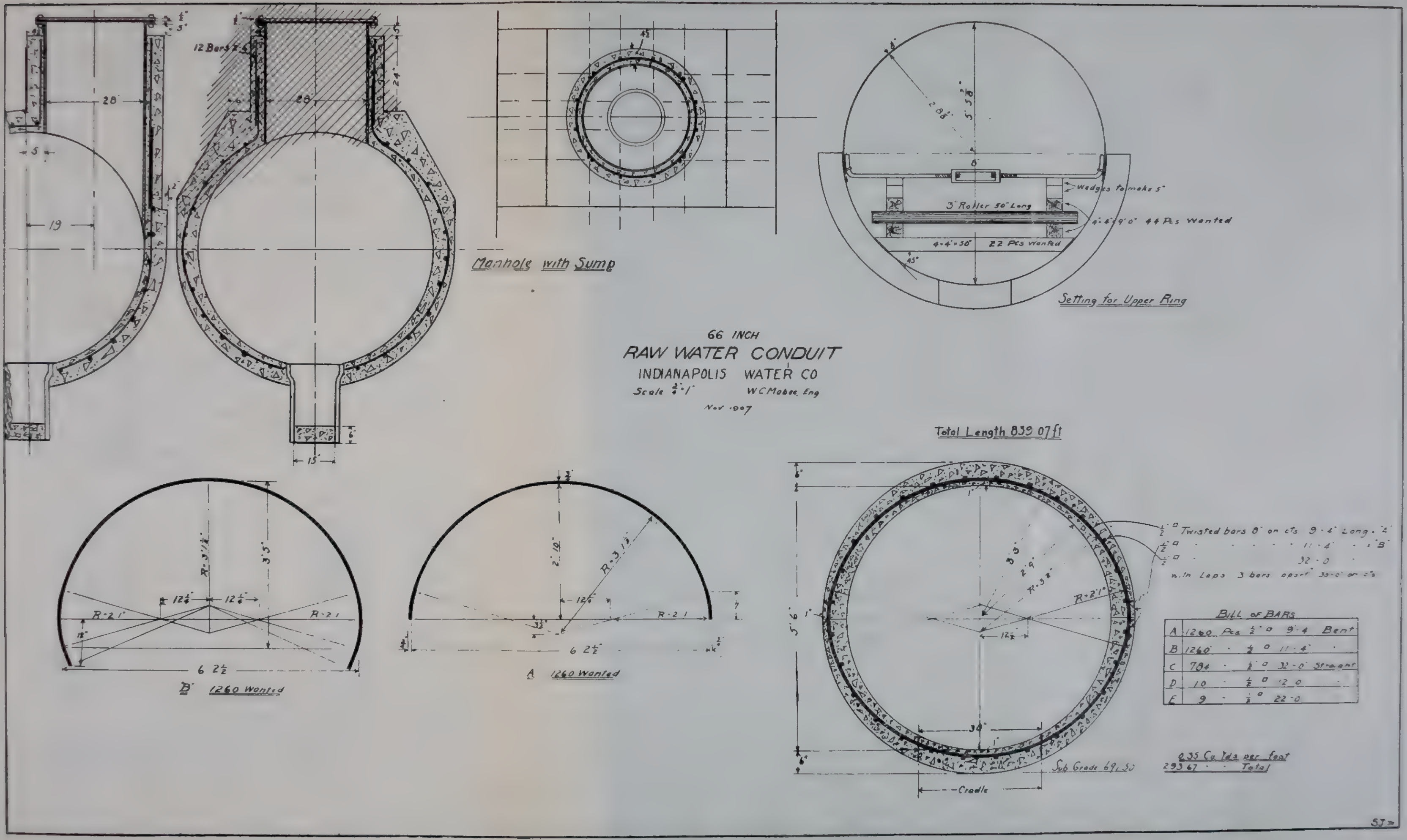


VIEW 15. PURE WATER RESERVOIR. VIEW ACROSS RESERVOIR SHOWING BARS IN WALL TO BE BENT DOWN INTO COVER SLAB. REFILLING, WITH LOCOMOTIVE AND CARS, IN BACKGROUND



VIEW 16. PURE WATER RESERVOIR. CENTRAL CONCRETE MIXING STATION, SHOWING CAR DUMPING CEMENT AND GRAVEL INTO THE SUPER-HOPPER AND SHUTTLE CAR LOADED WITH CABLE BUCKETS

FIGURE 3.



BILL OF BARS

A	1260 Pcs ½" ○	9' 4	Bent
B	1260 " ½ ○	11' 4"	"
C	784 " ½" ○	32' 0"	Straight
D	10 " ½ ○	12 0	"
E	9 " ½ ○	22' 0	

Excavation by machinery and cars 15,000 cu. yds	0.19
Excavation by teams 11,000 cu. yds	0.28
Refill 10,000 cu. yds	0.22

Placing Concrete per Cubic Yard

Floor	0.76
Walls	0.61
Cover	0.74

Cost of Bending and Placing Bars

Floor, 103 tons	4.63
Walls, 25 tons	11.37
Cover, 151 tons	6.46

Cost of Form Labor per Square foot of Concrete Surface Molded

In floor	$0.03
In walls	0.053
In cover	0.038

The concrete was mixed with a batch mixer using a cable way for distributing same and a shuttle car to convey the concrete from the mixer to the cable way.

The gravel was taken from the evcavation and was used unscreened and unwashed in the proportions of one part of cement to six of gravel.

The quantities involved were:

Concrete	cubic yards	5,195
Steel	tons	283
Cement	barrels	6,300
Gravel	cubic yard	5,700
Lumber	thousand feet	210
Excavation	cubic yards	26,000
Refill	cubic yards	10,000

Per Cubic Yards of Concrete

Cement	barrels	1.21
Gravel	cubic yards	1.10
Steel	pounds	1.09
Lumber	board feet	40

The greatest amount of concrete placed in one day of ten hours was 134 cu. yds., while the average amount for the concreting period was 70 cu. yds.

REINFORCED-CONCRETE PIPE LINE

This pipe line shown on Fig. 3 was built during the winter of 1907-08. It is 840 ft. long and is used for the purpose of conveying raw water to the precipitation basins.

It is laid 11 ft. below the hydraulic gradient. The inside diameter is 66 in. and the concrete shell is 6 in. thick. It is reinforced with ½-in. twisted bars spaced 8 in. on center in either direction. The pipe was built in three general operations after the ditch had been dug to dimensions corresponding to the outer circumference of the pipe.

A concrete cradle 30 in. wide was first laid to grade holding the lower circumferential rods, the rods heing held in position by curb boards notched out to receive them and also by the lower longitudinal rods. These lower circular rods were heated and bent in the field to the required shape and they were left long enough to project into the upper ring about 12 in.

Semi-circular metal forms were then placed on this cradle and fastened down by timbers laid across the tops and staked into the side of the trench to prevent the forms from floating.

The concrete was mixed in the proportion of one of cement, two of sand and four of gravel, and was poured into the space between the side of the ditch and the metal form, this operation completing the lower half of the pipe; the metal forms were then inverted and supported on wooden roller bearings and wooden track, as shown on Fig. 3. The upper rods were then fastened to the lower projecting rods and curved wooden forms were braced into position for molding the upper ring, leaving a space 18 in. wide open along the top for placing the concrete.

It was kept well churned and produced a smooth and perfect piece of work.

To facilitate the setting, as this work was done during the cold weather, gasolene torches were burned inside the completed portion until the whole was completed and the narrow exposed strip on top was protected by canvas. About one hundred feet of completed work a day was the usual progress, the metal forms being moved ahead in one hundred foot sections without disjointing. No cracks of any kind were discernible at the completion of the work and the pipe is watertight.

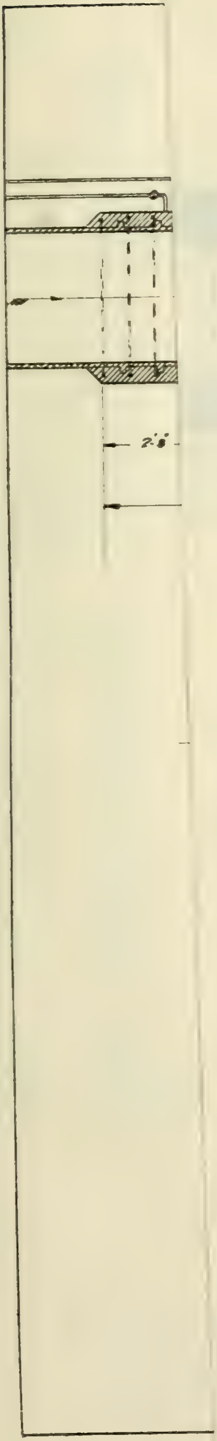

2'8"

FIGURE 4.

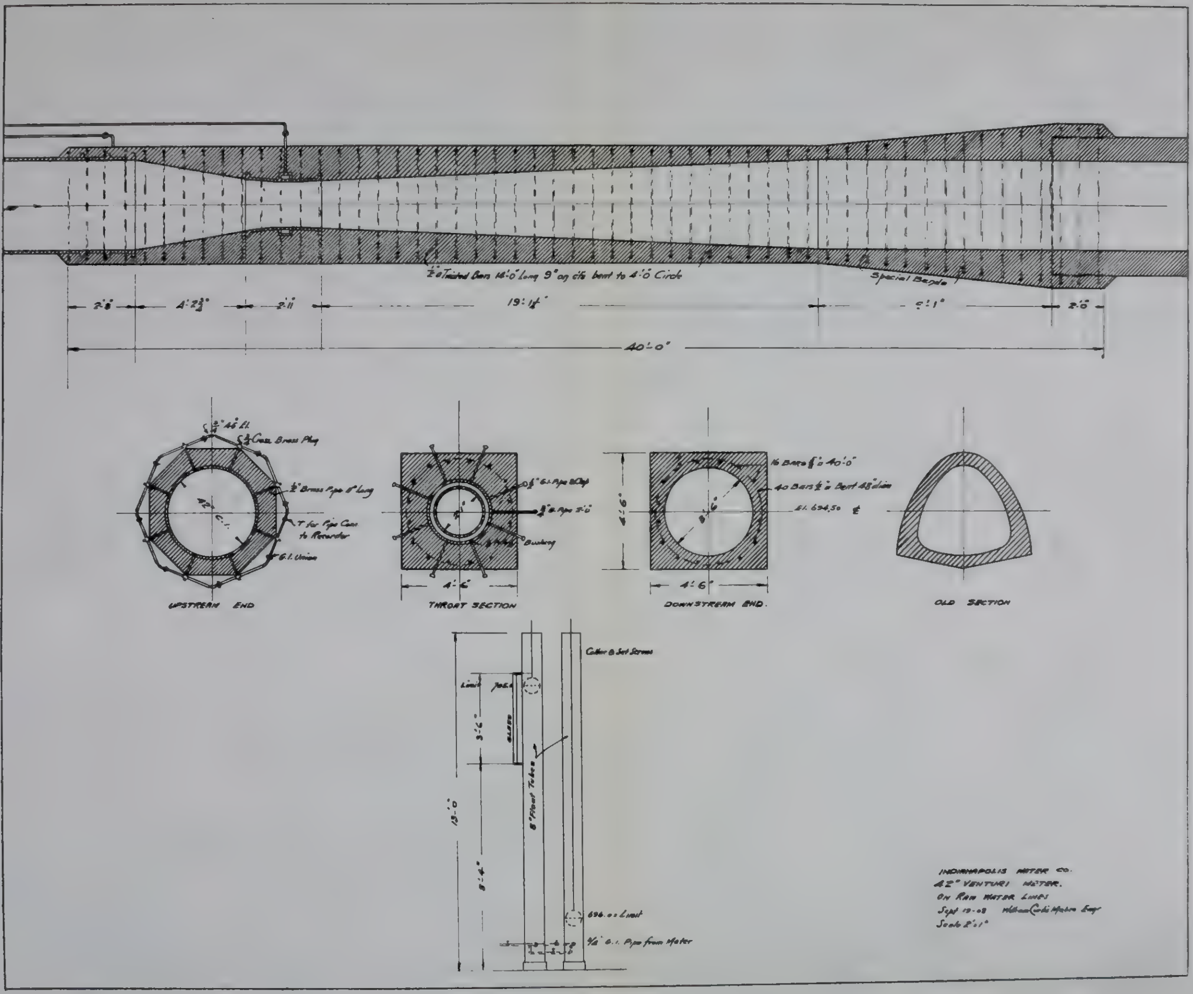
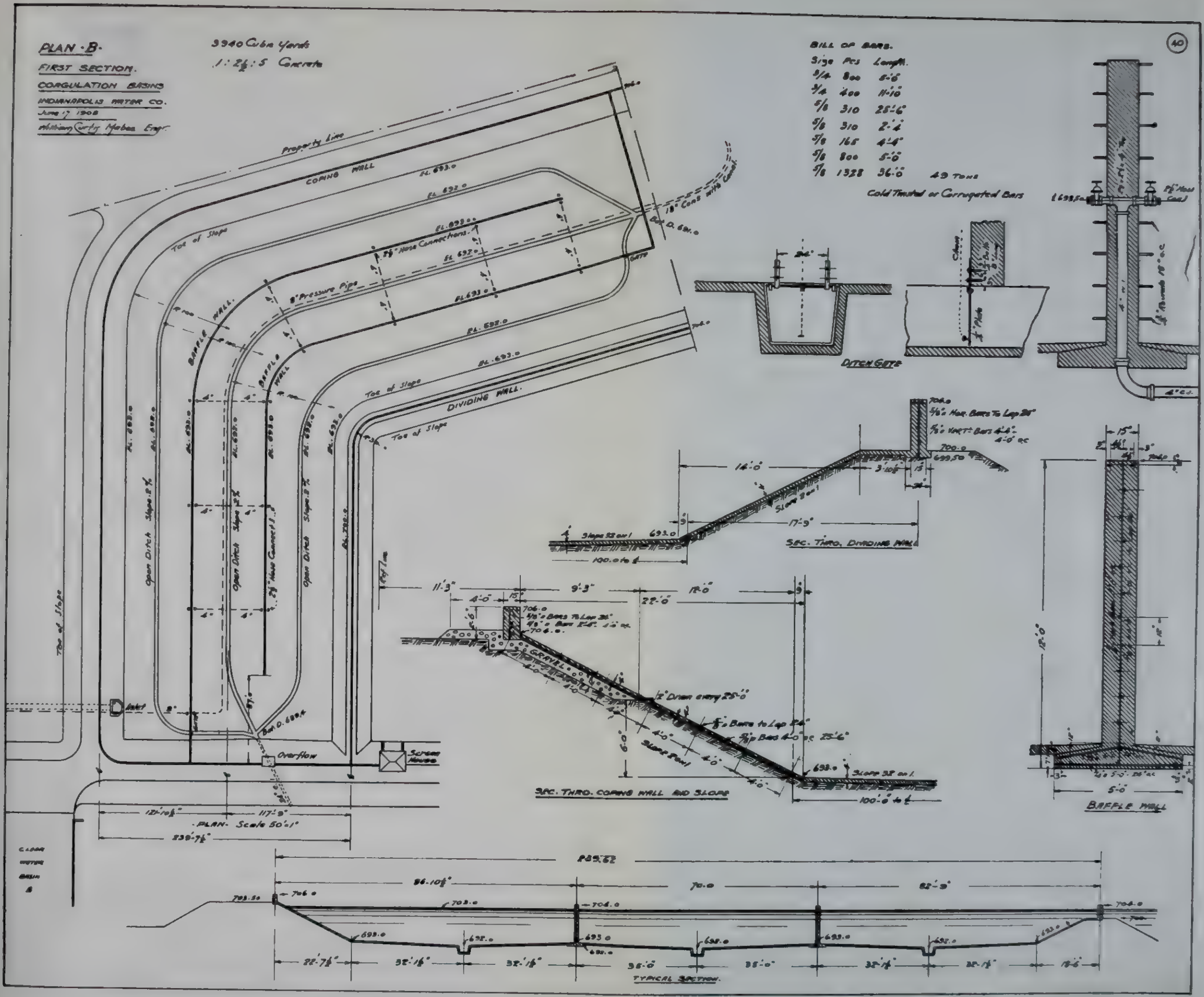

⅞" ⌀ Twisted Bars 14'-0" Long 9" on c/s bent to 4'-0" Circle
Special Bands
2'-8"
4'-2⅝"
2'-11"
19'-1⅛"
5'-1"
2'-0"
40'-0"
¾" 45° El.
¾" Cross Brass Plug
¾" Brass Pipe 6" Long
T for Pipe Conn. to Recorder
G.I. Union
42" C.I.
UPSTREAM END
½" G.I. Pipe & Cap
¾" G. Pipe 5'-0"
Bushing
4'-6"
THROAT SECTION
16 Bars ⅝" ⌀ 40'-0"
40 Bars ½" ⌀ Bent 48" diam
El. 694.50 ℄
4'-6"
4'-6"
DOWNSTREAM END.
OLD SECTION
Collar & Set Screws
Limit 702.0
Glass
3'-6"
6" Float Tubes
13'-0"
8'-4"
696.00 Limit
¾" G.I. Pipe from Meter
INDIANAPOLIS WATER CO.
42" VENTURI METER.
ON RAW WATER LINES
Sept 19-08 William Curtis Mabee Engr
Scale ⅜"=1'

FIGURE 5.


PLAN ·B·
FIRST SECTION.
COAGULATION BASINS
INDIANAPOLIS WATER CO.
June 17 1908
William Curtis Mabee Engr.
3940 Cubic Yards
1:2½:5 Concrete
BILL OF BARS.
Size Pcs Length.
3/4 800 5-6"
3/4 400 11-10"
5/8 310 25-6"
5/8 310 2-4"
5/8 165 4-4"
5/8 800 5-0"
5/8 1328 36-0"
49 Tons
Cold Twisted or Corrugated Bars
40
Property Line
COPING WALL
Toe of Slope
BAFFLE WALL
8" Pressure Pipe
2½" Hose Connections
DIVIDING WALL
Open Ditch Slope 2%
2½" Hose Connect.
Inlet
Overflow
Screen House
18" Conn. with Canal
PLAN Scale 50'=1"
121'-10½"
117'-9"
239'-7½"
DITCH GATE
SEC. THRO. DIVIDING WALL
SEC. THRO. COPING WALL AND SLOPE
GRAVEL
2" Drain every 25'-0"
100'-0" to ℄
BAFFLE WALL
5'-0"
TYPICAL SECTION.
289.62
86-10½"
70.0
82'-9"
22'-7½"
32'-1½"
35'-0"
18'-6"
CLEAR WATER BASIN B

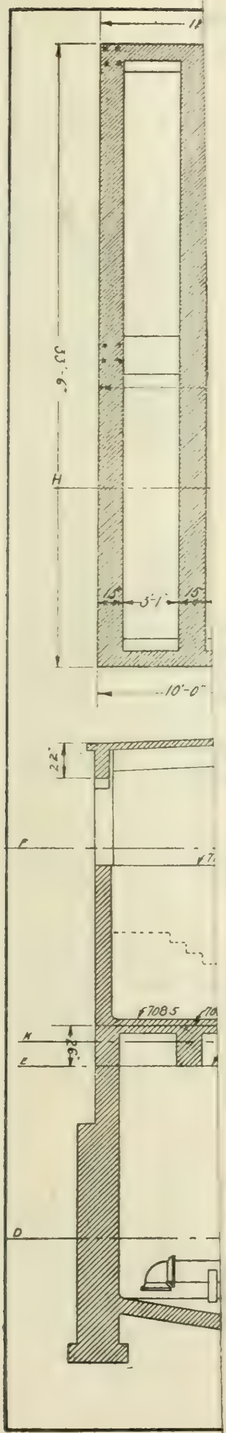
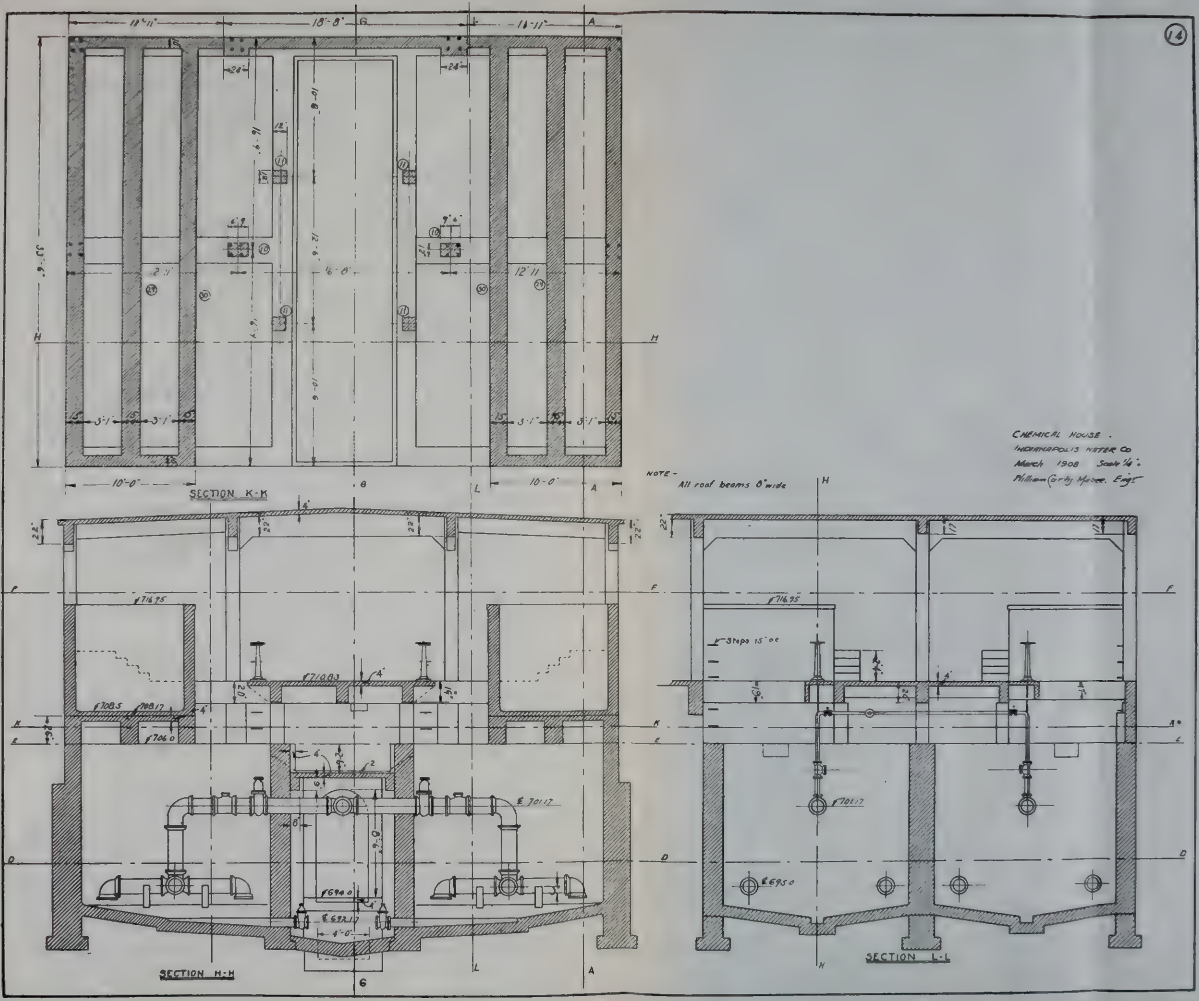

33'-6"
H
15"
3'-1"
15"
10'-0"
22"
F
708.5
K
26"
E
D

FIGURE 6.


14
18'-11"
18'-8"
18'-11"
G
A
24"
24"
35'-6"
16'-9"
10'-8"
12'-9"
12"
18"
16'-4"
10'-9"
6'-9"
9'-6"
21"
16'-8"
12'-11"
12'-11"
H
H
15"
3'-1"
15"
3'-1"
15"
3'-1"
15"
3'-1"
15"
10'-0"
10'-0"
SECTION K-K
G
L
A
NOTE -
All roof beams 8" wide
CHEMICAL HOUSE.
INDIANAPOLIS WATER CO
March 1908 Scale 1/4"
William Curtis Mabee. Engr
H
4"
22"
22"
22"
22"
F
F
F
F
716.95
716.95
Steps 15" oc
710.83
4"
20"
14"
708.5
708.17
4"
706.0
K
E
K
E
K
L
4"
12"
2
6"
8"
701.17
701.17
9'-0"
D
D
D
D
694.0
692.17
4'-0"
4"
695.0
SECTION H-H
SECTION L-L
L
A
G
H

The unit costs were as follows:

Per lineal foot of Pipe	
Placing centering and forms	0.958
Rental of metal centers	0.120
Steel reinforcing bars	1.054
Labor placing bars	0.258
Cement	0.674
Placing concrete	0.843
Hauling materials, including gravel	0.251
Engineering	0.054
Miscellaneous material	0.098
General construction	0.140
	$4.450

The pipe contained altogether 300 cu. yds. of concrete and the total cost was $12.46 per cu.yd.

The concrete was mixed in a batch mixer and wheeled an average distance of 500 ft.

Bids received on 60-in. light steel pipe proposed for this purpose on board cars Indianapolis ran from $6.70 to $7 a foot, one bid contemplation furnishing and laying in the ditch prepared by the company for $8.25 per ft.

Sixty inch light-weight cast-iron pipe would have cost $15.50 a foot f.o.b. Indianapolis, to which must be added the cost of lead and laying to make the costs comparative.

The cost of the concrete pipe did not include excavation, which would have been the same in either case; nor the cost of the gravel, which would add about 27c. a foot; so that the reinforced-concrete pipe cost about one-half as much as steel and about ¼ as much as cast iron; in addition it was 6 in. greater in diameter than either, besides having the advantage over steel of greater durability.

REINFORCED-CONCRETE VENTURI METER

With the installation of the preliminary treating plant, it became necessary to know how much raw water was being treated with chemical, and at the same time have the apparatus for recording and indicating these amounts at a convenient location to the operating headquarters. Accordingly a Venturi Meter 42 in. in diameter, having a throat diameter of 21 in., was built in the 42-in. raw-water conduit and the indicating apparatus was placed in the laboratory building. The working drawing of this meter is shown on Fig. 4; the throat section was of cast-iron and brass and was furnished together with the recording apparatus by the Builders Iron Foundry of Providence, R. I.

The conical forms were made up by the planing mill and worked on perfect lines and dimensions.

The concrete was mixed in the proportions of one of cement, one and one-half of sand and three of gravel.

The meter was built in the fall of 1908 and has been in service now for several months and is in every respect satisfactory.

PRECIPITATION BASINS

The plan of the coagulation basin shown by Fig. 5, is a part of the general scheme for clarifying the raw river water by coagulation.

The baffle walls are 70 ft. apart and are reinforced simply to prevent contraction cracks.

The embankments are of earth sloping two on one and are lined with a 4 in. slab of concrete, reinforced by $\frac{5}{8}$-in. twisted rods spaced 4 ft. apart in either direction.

The slab floor is 4 ins. in thickness and was laid in alternate blocks 8 ft. square.

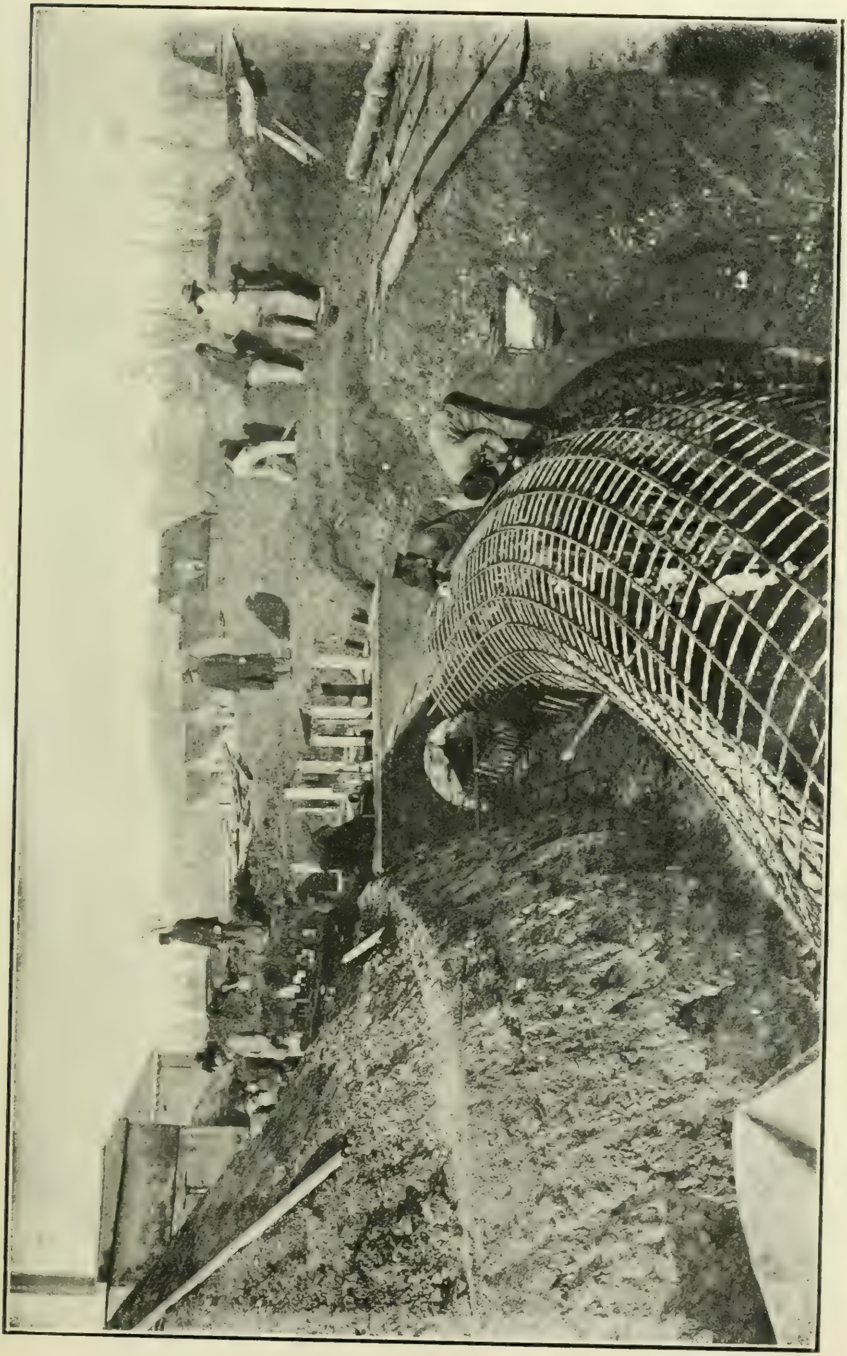
The floor slopes 1 ft. in 35 to the open ditches, which in turn slope $\frac{2}{10}$ ft. to the 100.

Water pressure pipes are laid as shown in view No. 19 with hose connections built into the baffle walls as shown in Fig. 5 to facilitate the flushing out of sludge during cleaning periods. This portion of the precipitation basin was built during 1908 and went into service last November.

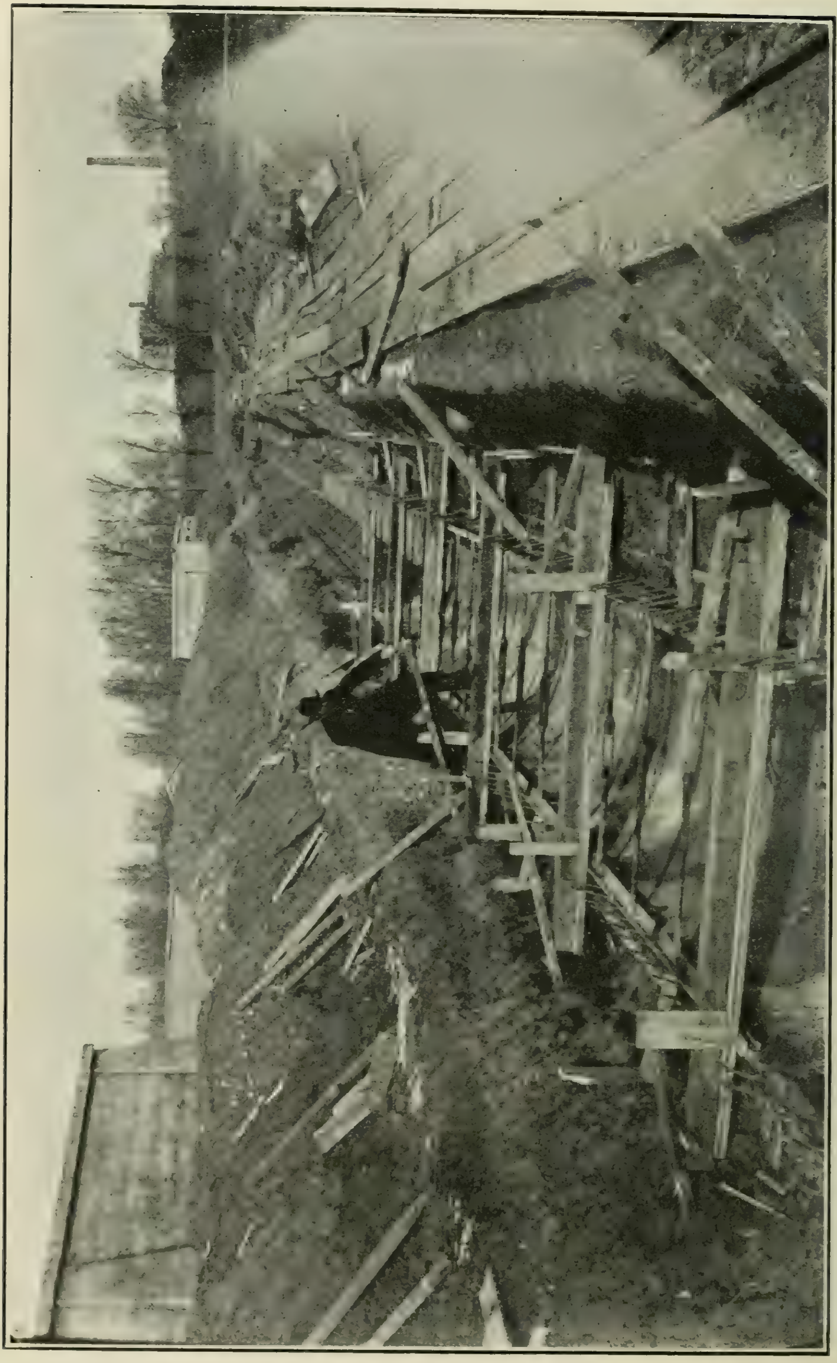
REINFORCED-CONCRETE CHEMICAL HOUSE

In connection with the coagulating basins and for the purpose of treating the raw water at seasons of excessive turbidity, there was built a chemical treating house shown in section on Fig. 6 and illustrated by view No. 21. The lower part of the building is principally lime saturating tanks, over which are built the iron solution tanks.

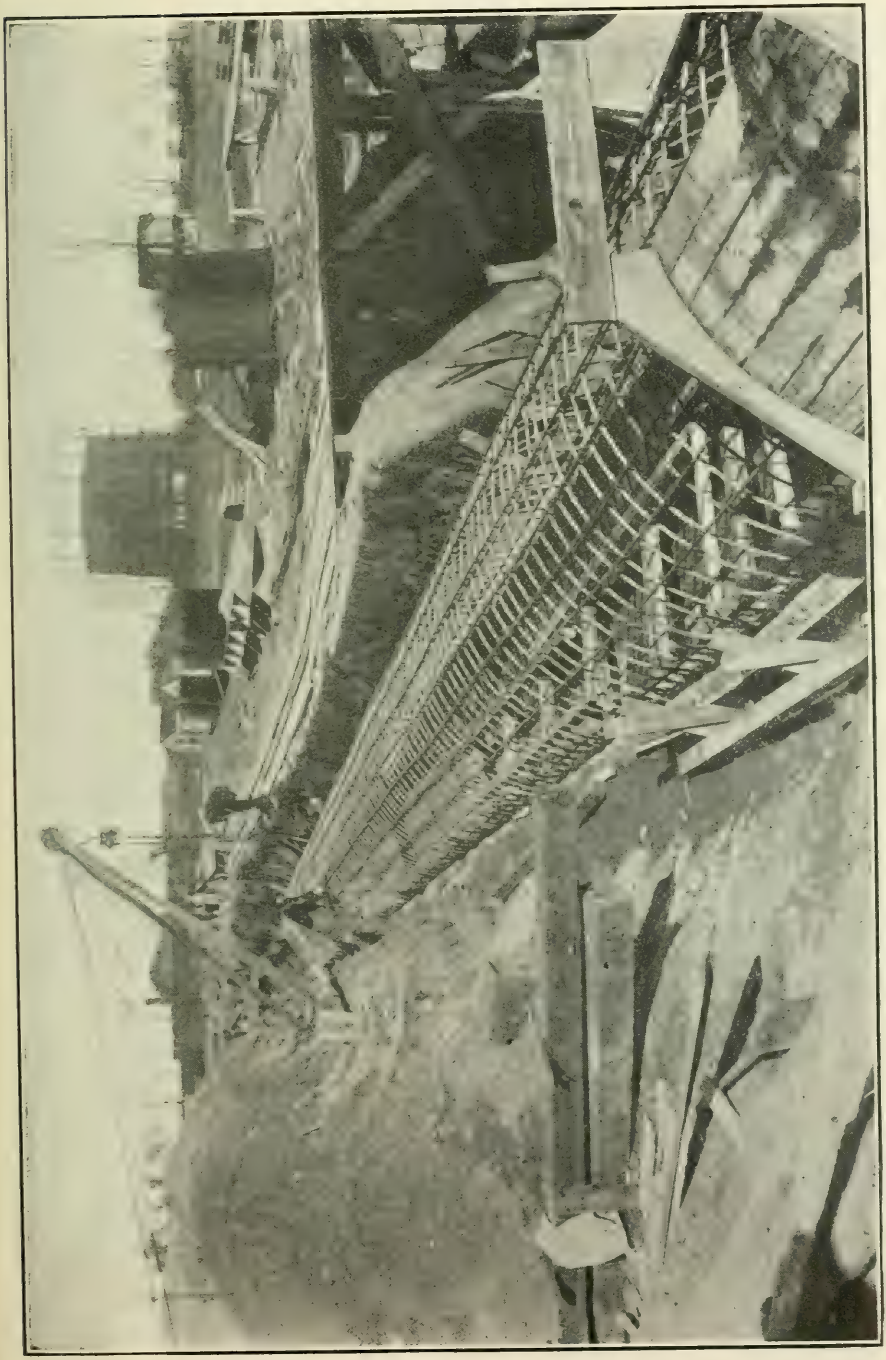
The columns, floors, walls, stairways, roof and tanks are of reinforced concrete throughout.



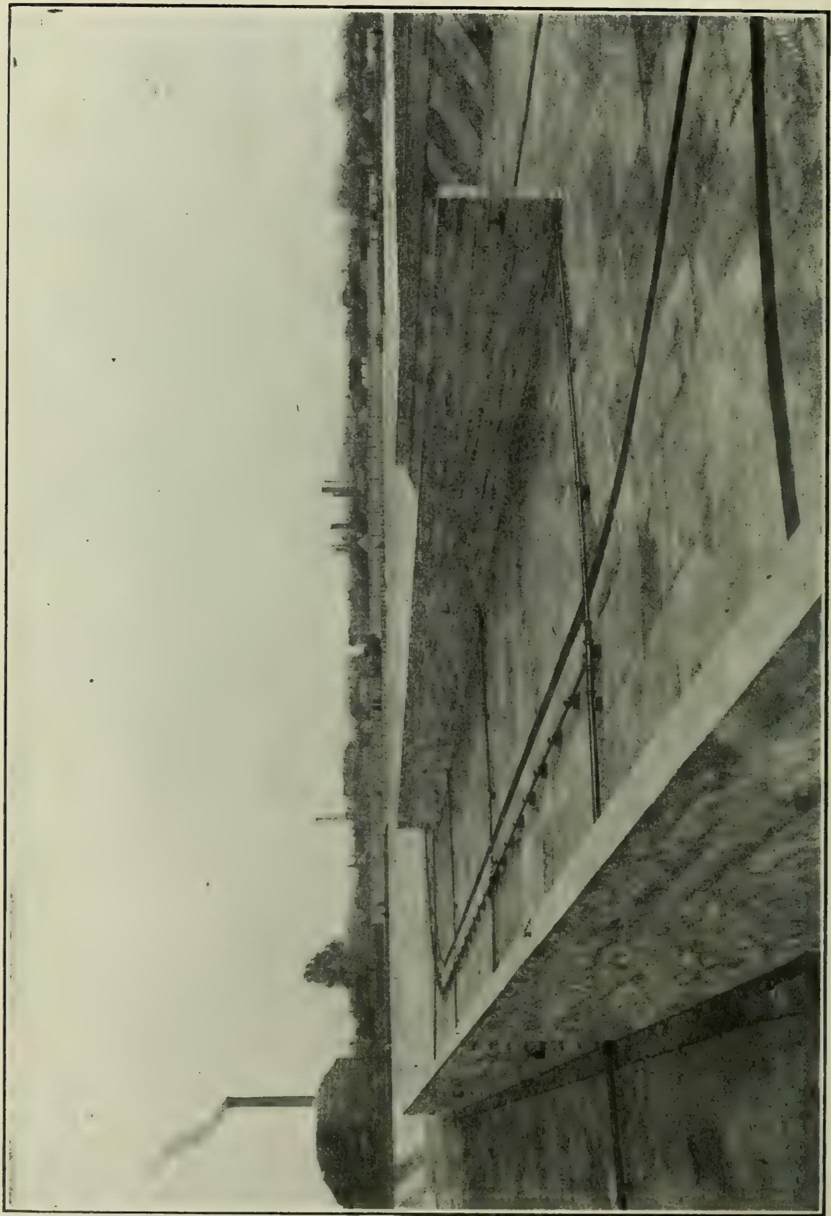
VIEW 17. 66-IN. CONDUIT. ON 45-FOOT RADIUS AND TERMINATING IN GATE CHAMBER



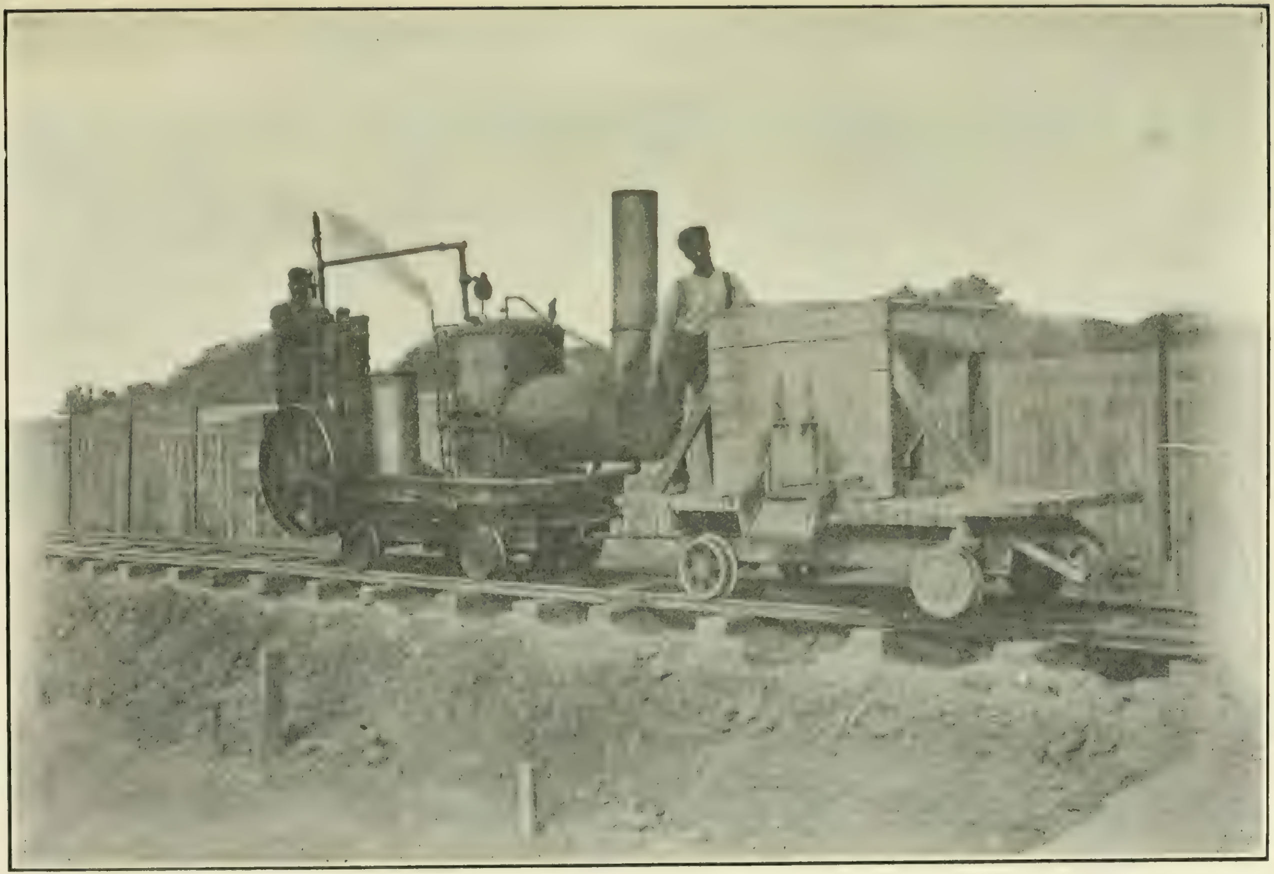
VIEW 18. 66 INCH PIPE LINE. LOWER HALF OF PIPE LINE SHOWING CRADLE HOLDING RODS IN POSITION AND TIMBERS ANCHORED TO SIDES OF TRENCH



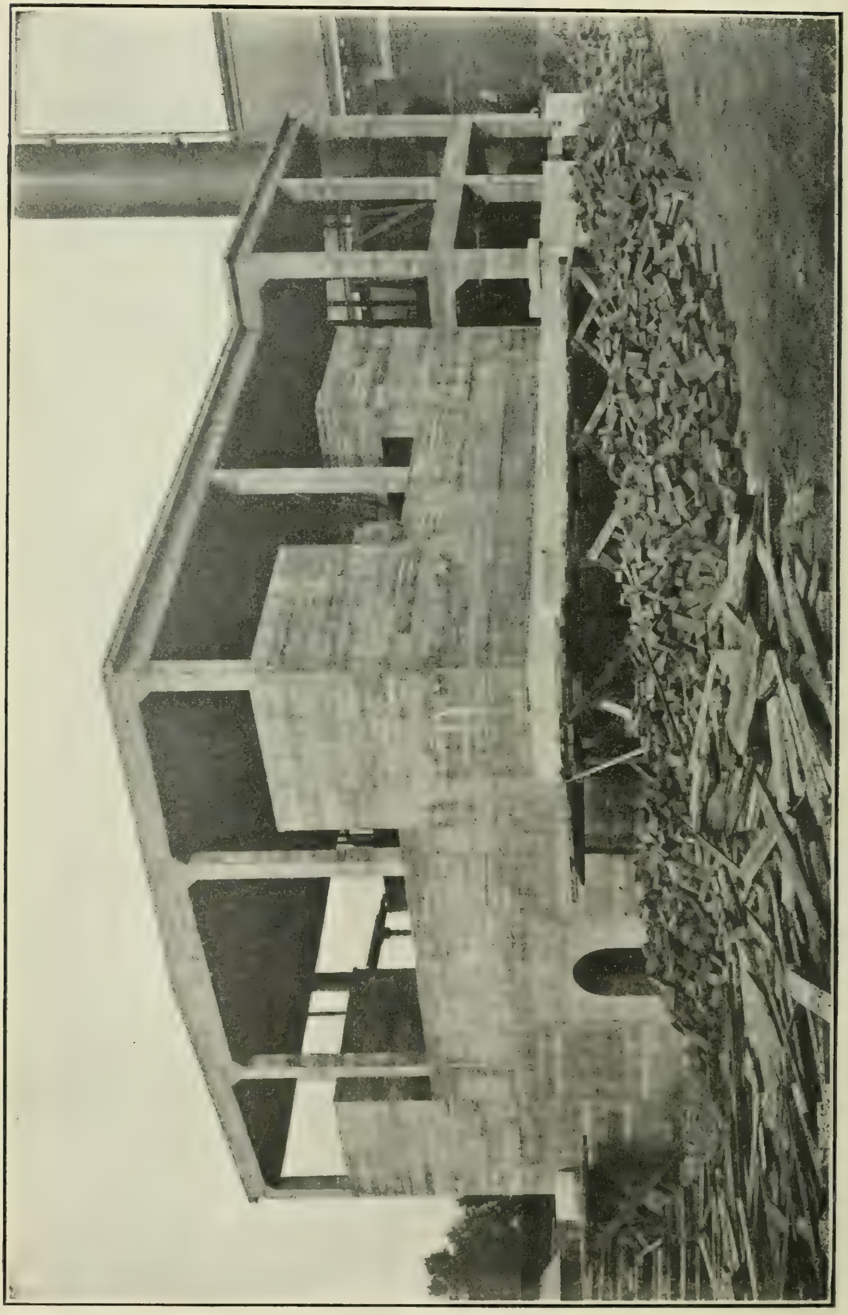
VIEW 19. REINFORCING BARS IN POSITION. 66-IN. REINFORCED CONCRETE PIPE LINE SHOWING FORMS FOR INNER AND OUTER SURFACES OF UPPER HALF



VIEW 20. GENERAL VIEW OF COMPLETED PRECIPITATION BASIN. SHOWING FLUSHING PIPES AND $2\frac{1}{2}$ IN. HOSE CONNECTIONS BUILT INTO BAFFLE WALLS



VIEW 21. IMPROVISED LOCOMOTIVE AND HOPPER CAR USED IN CONSTRUCTION OF PRECIPITATION BASINS, CONVEYING CONCRETE FROM THE CENTRAL MIXING STATION TO THE DIFFERENT PARTS OF THE WORK. THIS INVENTION WAS MADE NECESSARY BECAUSE OF THE CURVES IN THE WALLS AND THE SPREADING CHARACTER OF THE WORK

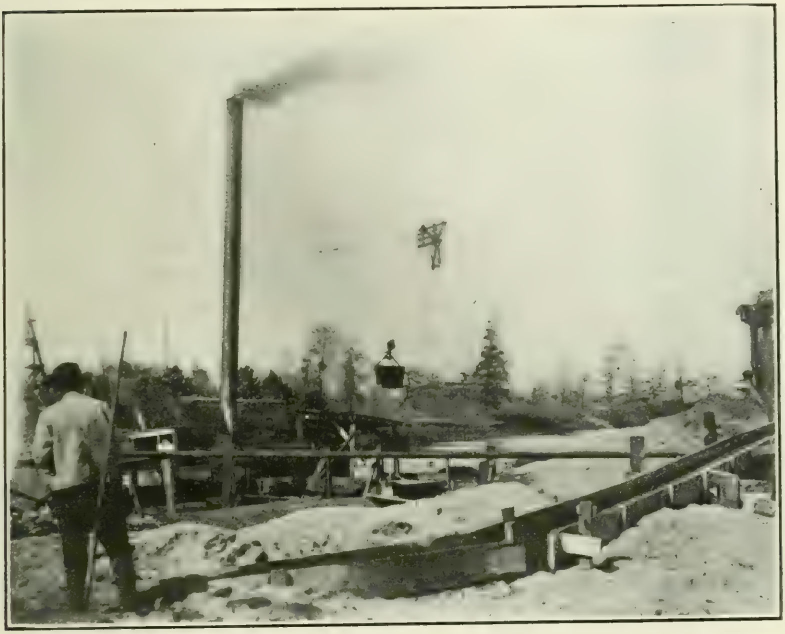


VIEW 22. CHEMICAL HOUSE. SHOWING CONCRETE TANKS AND ROOF

The building is veneered with pressed brick and stone trimmings.

In connection with the iron solution tanks, it was observed that any tendency for water to percolate through the concrete was promptly checked as soon as the sulphate of iron solution was introduced.

All tanks were built monolithic as boxes, in one operation and independent of each other. This work was done during the first half of the year 1908, and the building is now in service. Mr. George W. Fuller, C.E., was consulted on this work.



VIEW 23. PRECIPITATION BASIN. GRAVEL EXCAVATING MACHINE DREDGING FALL CREEK AND DUMPING GRAVEL ON SCREENS WHERE IT IS WASHED AND SEPARATED INTO GRADES

These examples of concrete construction are given merely as an indication of how valuable this material has become and illustrate in part the usefulness to which concrete can be put in the development of waterworks generally.

METERS AND METER RATES

W. VOLKHARDT

Meters and meter rates have been discussed many times before this and other associations of a similar character. Some contend that it is a threadworn subject. This may be partly true, but had the threads been properly cut in the first place, conditions and results would be vastly different; therefore, this discussion will continue until the fundamental principles are firmly established and in use.

Those fundamental principles are, (1) Increasing the capacity of water supplies without the use of additional reservoirs, pumps, springs and mains. (2) The re-adjustment or equalizing of water charges to the consumer.

To make the use of meters effective a rate should be established based on conditions existing in the plant to be metered and not on what some other plant is charging. I hold that the rate is the backbone of the system. If that is weak, it won't carry you through successfully. This contention is based on actual experience. I further contend that this work should be done when the first meter is installed, even if it be but one meter, and that the rate should be based on a universal system, whether it is the intention or not to install a complete system.

Some writers take the stand that the price of water should be based absolutely on cost. I cannot agree with them, because new money is needed every year for betterments, renewals and extensions. Further, as the plant grows year by year, this expense increases correspondingly. Gravity plants have very small indebtedness. If the policy of selling water at cost prevails, consumers on such plants would be getting their water in a few years for little or nothing. Many small towns which have gravity plants rely upon the water fund for their main support for the upkeep of the town; therefore, that plan could not be followed generally.

Some cities and towns have adopted the plan of charging the consumer with the cost of the meter and then selling the water somewhat cheaper; this is only another form of securing the required revenue. It has been found that the plan of covering the cost of the meter and its installation, in the rate, is more satisfactory and more inviting to the consumer than that of charging for the meter direct. I can see no good reason why he should be charged for the meter than to be charged for a fire hydrant that may be set in his neighborhood. I think meters should be owned, installed and kept up by the plant and be considered a part of the water works system.

Some discussion has been indulged in regarding the sliding scale of meter rates, but I note that such discussions have been mostly by the managers of large plants. The sliding scale that will give a consumer a lower rate by wasting water I consider wrong. Such a scale prevents the meter performing the function for which it was intended, furthermore it gives certain consumers an advantage over others, but I do indorse the sliding scale which charges all consumers alike for the same quantity of water; such a scale does not invite waste. Some have contended that it is not fair to the small consumer to charge him more than the large consumer. I have my doubts of a universal system being successful with but one single rate, for the reason that we find in practice that the ordinary family of five persons with kitchen and bath room fixtures, do not require or use more than 3000 gallons per month. Suppose, then, the rate to be 10 cents per thousand gallons; that would yield 30 cents per month or $3.60 per annum. How many plants can live with such a small income? I happen to know of two towns which tried the 10 cent rate to all and failed, the meters were taken out and all placed back on a flat rate. When the subject of meters is up in either town they say that meters are a failure. The meters were not, but the plan adopted was.

The large consumer is mostly situated in a congested section of the city, with his place of business mostly up in the air, so to speak, and not spread over much territory, while on the other hand the small consumer is located in a residential section where only a few houses are erected to the block and the return per mile of mains is much smaller. I fear the wholesale and retail feature will have to be recognized. It may be possible to be successful with two rates in the larger cities, say 20 cents for the first five or ten thousand gallons and 10, 8 or even 6 cents for all over that amount. It would be interesting to know if there is any large universal system operating successfully on a single rate of 10 cents or under. It must be understood that you cannot work without a minimum rate and, to my mind, that minimum should not be less than $6 per annum for municipal plants and $9.00 per annum for private plants.

I know of a large city that has commenced to establish a universal system, and until completed must charge the same rate as has been charged to commercial users, viz: 4 cents per thousand. The minimum flat rate is $4.50 per annum for dwellings of a certain size. This charge predominates, which accounts for my using it as an example. Under it an allowance of 112,200 gallons per annum is made. You can see at once that meters are not reducing the waste very much. With some 13,000 meters now in use, very few run over the minimum and when they do it generally proves to be the result of a leak.

Right here I wish to bring out another important feature of the meter schedule; that is, the reading and charging by the month instead of longer periods. If the schedule is compiled for monthly work, the minimum applies for that period and the amount allowed must be consumed during that period or the consumer loses and the system gains. If the periods are for three, six months or one year the system loses much, as the consumer can then economize during certain periods and pull heavily on you just when you need the water most, or he may be absent for a part of a long period. If you will contract for a short period you will increase your revenue, or, in other words, you will get all that there is to get.

The writer considers it is advisable to give a special rate or a flat low meter rate to steam railroads, because they are large users of water and the revenue derived from such a consumer increases your gross revenue to such an extent that you can sell to the small user for less than if you did not have the railroad revenue. I have seen this demonstrated in more than one instance.

CHEAP TRANSPORTATION AND DELIVERY OF PUBLIC WATER SUPPLY

HARRY C. HEERMANS

The writer for many years had the management of the Corning, New York, Water Works where rates were established on a basis of equality with the charges for water in surrounding cities and towns. The water office frequently received protests from consumers that bills were excessive, even where rates were reasonable and the manager was often accused of being unreasonable, a monopolist, and more or less a mercenary fiend. This spirit of antagonism has increased in recent years with the popular prejudice and hostility against the corporations.

In 1898 the writer constructed a water works system in Hoquiam, Washington, then a small seaport town, but now a manufacturing city with 14,000 population and rapidly growing. He also in 1905 acquired the management of the water works at Olympia, Washington, the capital of the state; a growing city with a present population of 12,000.

Water rates on the Pacific Coast average 50 per cent higher than the Eastern states. This increase is because of the higher cost of materials and labor for construction purposes.

The population here is largely made up of active, energetic, never-say-fail young people of the states who have seen in the thriving resourceful state of Washington unequalled opportunity for success in life. And by success, I mean that achievement which comes to a few persons in the East in a lifetime by many years of faithfulness, economy and perseverance; that same success is acquired in the West by similar methods in a few years. Here the methods, predilections and prejudices of the East are all grounded in human nature and intensified by great activities; and the result is an acute, nervy individual who believes that his imported knowledge is positive and absolute. In conjunction with this type is the crank, the labor agitator and the socialist, who seeks a new clime to elucidate his opinions and instruct the commonwealth how to formulate its law. This latter class is the serious problem of the state, which temporarily suffers to some extent by class agitation; yet the conservative, wise and competent business men are gaining the control and the marvelous development of vast resources results in the rapid building of cities and towns in the State of Washington.

The management of private water corporations therefore requires unusual skill and tact to satisfy an intense public sentiment for good service. This demand for good service is more exact and positive than in the East; it is impatient; it will not submit to promises and delays; yet it is liberal when service is rendered and does not question the cost in rates. These are unusual conditions and are sources of encouragement to the successful manager. If aggressive, he becomes an important factor in development; his troubles are minimized, and his business life ceases to be a burden to himself and to the town. Woe to the manager with imperfect service. Agitation at once becomes active, fierce and impatient; and the unrelentless remedy is to drive him out of business. At times this opposition becomes unreasonable and outrageous; for the manager is not always in condition financially to meet the growing demands of rapidly increasing communities.

Along this line education of the public becomes necessary; the growth, the investment, the service, all the local conditions must be explained to an expectant people. As a rule, managers are so occupied with details of management that no time is given to the educational branch of the service. This silence often produces serious conditions in a locality where hostility is strong. Many semi-public corporations have of late recognized this defect in management and have begun to issue stated announcements in the press for the purpose of education and the due consideration of the problems confronting the business. This movement is along the right line, and has proved to be profitable in results. In the experience of the writer, this policy became a necessity and has been adopted as an answer to criticism and for the good of the service.

Few water consumers ever stop to think about the collection and delivery of a water supply. Where it is obtained; how far it is carried and the service enjoyed from a good and pure water system; its delicate conditions of management; its storage; its weight; its relative cost of transportation to other commodities; or the saving to the consumer over other methods of securing a domestic supply.

For the purpose of information, the Hoquiam Water Company has issued the following bulletin to its consumers, which has proved valuable and has answered many unfavorable objections and criticisms offered at the water office:

BULLETIN TO CONSUMERS OF THE HOQUIAM WATER COMPANY

Hoquiam, Washington

HARRY C. HEERMANS, *Pres.*

Cheap Transportation and Delivery of Public Water Supply.

Examine the tables in this bulletin. They will agreeably surprise you. Please remember in paying your water bill that you pay for the collection, pumping, and delivery of an adequate water supply, *when* you want it, *where* you want it and in quantity to supply your requirements. No worry. Your rate is based on the quantity required for the uses you specify in your application to the Water Company. You do not pay for wastage and you are therefore requested to treat the Company fairly and prevent waste. That is the only square deal. Think of the luxury and cheapness of a public water supply. You make no investment for wells, or cisterns, or storage tanks; no labor at home pumping water or cleaning cisterns, wells, or tanks, and no payment of constant repairs to the same. The public supply furnishes your home with hot or cold water everywhere if you want it and is the cheapest commodity you buy.

Think of these facts and smile when you pay your bill to the Water Company.

COST OF WATER, DELIVERED BY WEIGHT, ACCORDING TO VARIOUS RATES, THROUGH WATER WORKS SYSTEMS

Attention is called to the fact that the delivery of water by weight, through public water supply systems, as a commodity is the cheapest in the known world, in comparison with other transporation; for instance, the switching of a car containing fifteen tons of freight, switched within the city limits by any railroad company, would not be less than $2.00, or 12⅔ c. per ton.

Last summer the Hoquiam Water Company paid for the switching and transportation of car-loads of water pipe a distance of not over two or three miles, the sum of $15.75 per car, or .877c. per ton.

We are now collecting the Hoquiam Water Supply at the average distance of five miles from town, pumping and delivering the same to consumers in their homes at any elevation required not exceeding 200 feet above sea level, at the rates per ton as shown in the following table:

Price per 1000 gallons delivered through water works system	$0.08	.15	.20	.30	.45	.50
Price of water per ton, delivered by various Water Companies	$0.019	.036	.048	.072	.107	.119

One thousand gallons of water weighs 4.175 tons.

One gallon of water weighs 8.35 pounds.

One cubic foot of water weighs 62.42 pounds—(Trautwine).

One cu. ft. of water contains 7½ gallons.

THE REASON WHY WATER TAKERS SHOULD PREVENT LEAKS IN PLUMBING FIXTURES.

Data Taken from Book on Hydraulics by Geo. A. Ellis, C.E.

Amount of water, in gallons, that will pass through pipes or jets of various sizes in one hour under different pressures of the Hoquiam Water Company:

SIZE OF OPENINGS.	85 LBS. PRESSURE.	90 LBS. PRESSURE.	95 LBS. PRESSURE.	100 LBS. PRESSURE.
1–16 inch	64.2	66	67.8	69.6
1–8 "	258.6	265.8	273	280.2
3–16 "	577.2	593.4	612	624
1–4 "	1032	1062	1090	1122
3–8 "	2310	2376	2442	2502
1–2 "	4128	4248	4368	4476
5–8 "	6420	6600	6780	6960
3–4 "	9300	9600	9880	10080
7–8 "	12600	13020	13380	13680
1 "	16500	16980	17460	17940

RULES FOR THE USE OF WATER.

The following acts are prohibited:

1 Allowing water to run to waste; or to run to prevent freezing.

2 Having leaky water fixtures on the premises.

3 Using a hose without a nozzle.

4 Using a nozzle with an orifice of more than one-fourth of an inch.

5 Using water through a hose unless hose is held in hand.

6 Using water through a hose between the hours of 9:00 a.m. and 5.00 p.m.

7 Using an automatic sprinkler at any time unless such sprinkler is connected on a meter.

8 Using water through a hose during the progress of a fire in the city, except upon the fire.

9 Using water through any plumbing fixtures without first applying for and obtaining permission for such use.

10 Allowing water to be taken from premises by persons having no ight to its use.

11 Wilful waste of water in any way.

A CHEMICAL AND BACTERIOLOGICAL LABORATORY ELECTRICALLY EQUIPPED

S. T. POWELL

Chemist and Bacteriologist

The comment is often made that electrical regulating devices are as a rule unsatisfactory. It is for this reason that the writer has undertaken a brief description of a laboratory so equipped that has given entire satisfaction. The laboratory of the Baltimore County Water and Electric Company is particularly unique in the respect that practically all the heating and regulating devices used are operated by electricity.

In place of the Bunsen or other gas burners usually seen in laboratories, electric stoves are used. These stoves require 755 watts at 110 volts and can be run on three heats: low, medium and high. The hot-air sterilizers for sterilizing glassware are electric ovens, requiring 1100 volts 110-volt current and, like the stoves, can be operated at three different heats.[1] Hot water is furnished by an H. C. K. instantaneous hot-water heater. This piece of apparatus is very useful where much hot water is needed. It requirès 20 amperes at 110-volt current.

For evaporating solutions over water an ordinary water bath is used, the heating being done by an electric coil. The coil is so designed that when once the water is brought to the boiling point on the high heat the current is reduced to the medium heat, and 100 cc. of water in an evaporating dish can be run to dryness in two or three hours, the time of evaporation depending on the transmission of heat of the material of the dish.

The incubator for growing bacteria at blood temperature is both heated and controlled electrically. The heating is done by a coil in the water jacket similar to the water bath mentioned above. The thermostat regulating the temperature is inserted

H. C. H. Electric Heating Company, New York City.

in the water surrounding the incubator. As the temperature of the water increases the column of mercury in the thermostat rises until it comes in contact with a platinum wire suspended in the tube. By this contact a circuit is formed between a series of batteries and a relay switch.

The coils of the relay becoming magnetized draws to them a movable arm and by so doing breaks the current heating the coil in the water jacket of the incubator. With the lowering of the temperature of the incubator the column of mercury falls below the platinum wire and in this way the coils of the switch are demagnetized; the arm flies back in place by a spring and the heating of the incubator begins again. The temperature required is accomplished by adjusting a screw to which the platinum wire is attached. This piece of apparatus has given entire satisfaction and requires less care than most devices used for the purpose.

The 20° C. incubator is controlled by a metal expansion thermostat. As the temperature of the incubator rises above that required, the expansion of the metal disc of the thermostat[2] coming in contact with a needle, a circuit is formed between a series of batteries and the clutch of a spring motor. The clutch is released and the shaft of the motor turning over thereby opens a valve, allowing ice-water to flow through the water jacket of the incubator. When the incubator is sufficiently cooled, the contraction of the disc breaks the current and the ice-water valve is closed. This thermostat is not as sensitive to temperature changes as is the mercury thermostat used for regulating the 37½° C. incubator, described above. For this reason the metal thermostat is soon to be replaced by the mercury one.

For determining the B.t.u. in coal[3] a Parr standard calorimeter is used. The ignition of the coal in the bomb of the calorimeter is accomplished by electricity. The water surrounding the bomb is agitated by vanes which are driven by a small K. & D. electric motor. The current is supplied by a[4] motor generator set. The current enters the motor end of the generator at 110 volts 60 cycles *A.C.* and leaves the generator at 6¼ amperes 12 volts *D.C.*

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[2] Queen City Electric Company, Elmira, N. Y.

[3] Parr Standard Calorimeter Company, Moline, Ill.

[4] Holtzer-Cabot Electric Company, Boston, Mass. All electric apparatus, unless otherwise stated, was furnished by the Simplex Electric Heating Company, Cambridge, Mass.

The operation of the filter plant[5] is all done electrically and controlled by switches situated in the laboratory.

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[5] A description of this plant will be found in the *Engineering News*, March 18, 1909.

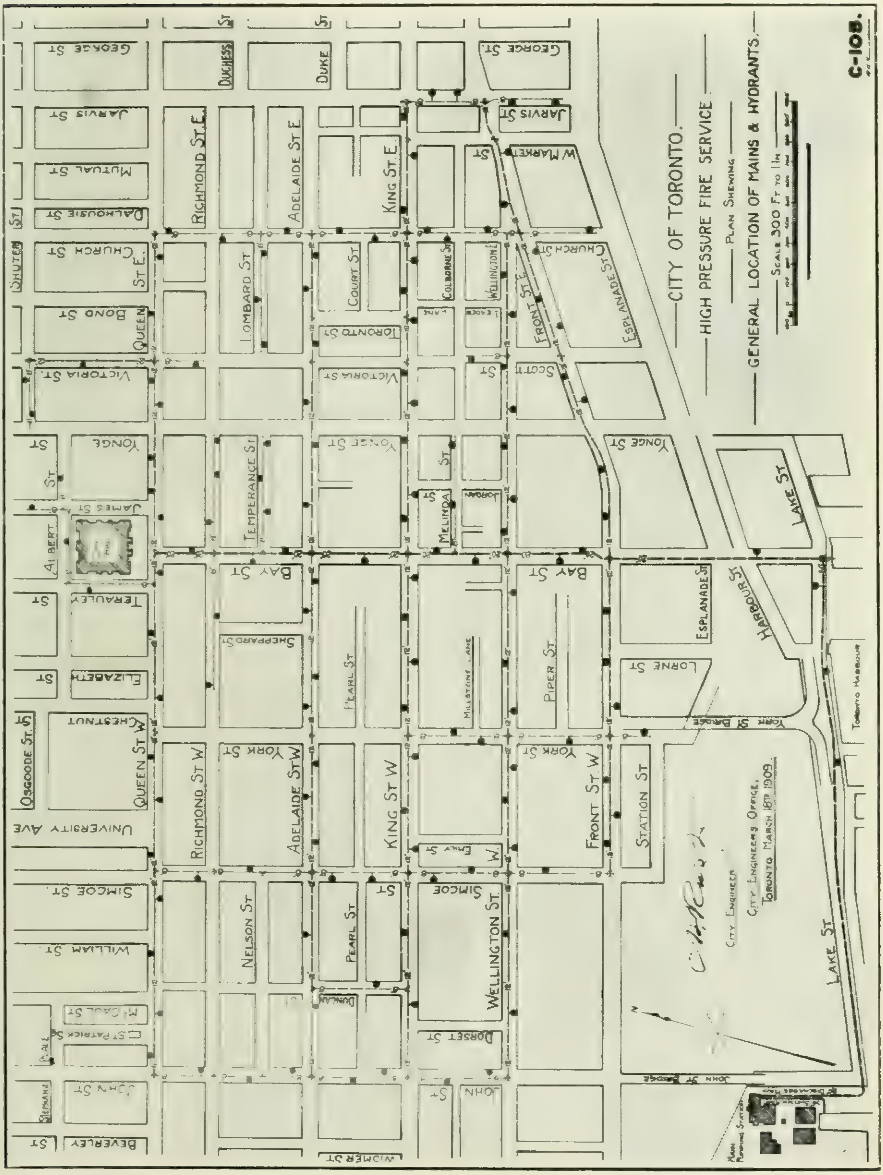
TORONTO HIGH PRESSURE FIRE SYSTEM

C. L. FELLOWES.

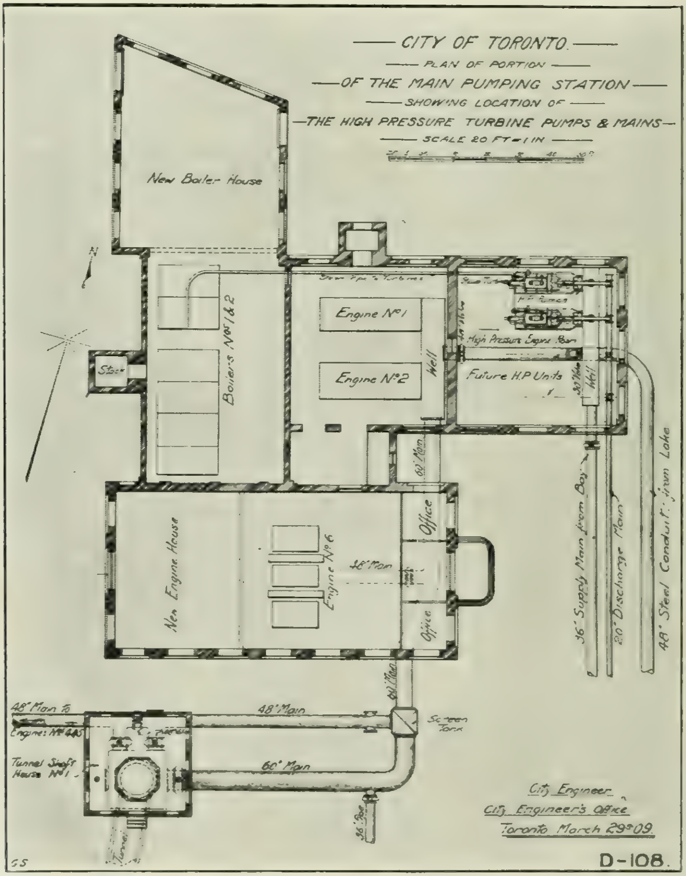
The conflagration of the nineteenth of April, 1904, by which over $10,000,000 worth of property was destroyed, resulted in the underwriters raising the rates on all fire risks lying in the congested business district for wholesale and retail houses covering an area of over 300 acres, extending from John Street east to Jarvis Street and from the Water Front to Queen Street. This increase in rates started an agitation for better fire protection throughout the district, the Board of Trade and Merchants demanding a high pressure system, similar to that installed in Philadelphia; this was supported by a promise from the underwriters to reduce the rates as soon as a satisfactory system was in operation.

A deputation of the Council, with the Fire Chief, visited a number of the cities in this connection, returning fully impressed with the advantages of such systems, particularly that of Philadelphia. Before finally deciding on the best method of operation the writer visited Philadelphia, New York and Pittsburg. The conclusion arrived at was that admirable as were the Philadelphia and New York systems, neither of them suited Toronto conditions, gas and electric currents could only be obtained in each case from one source. In addition it involved practically the use of sewage polluted bay water for all time.

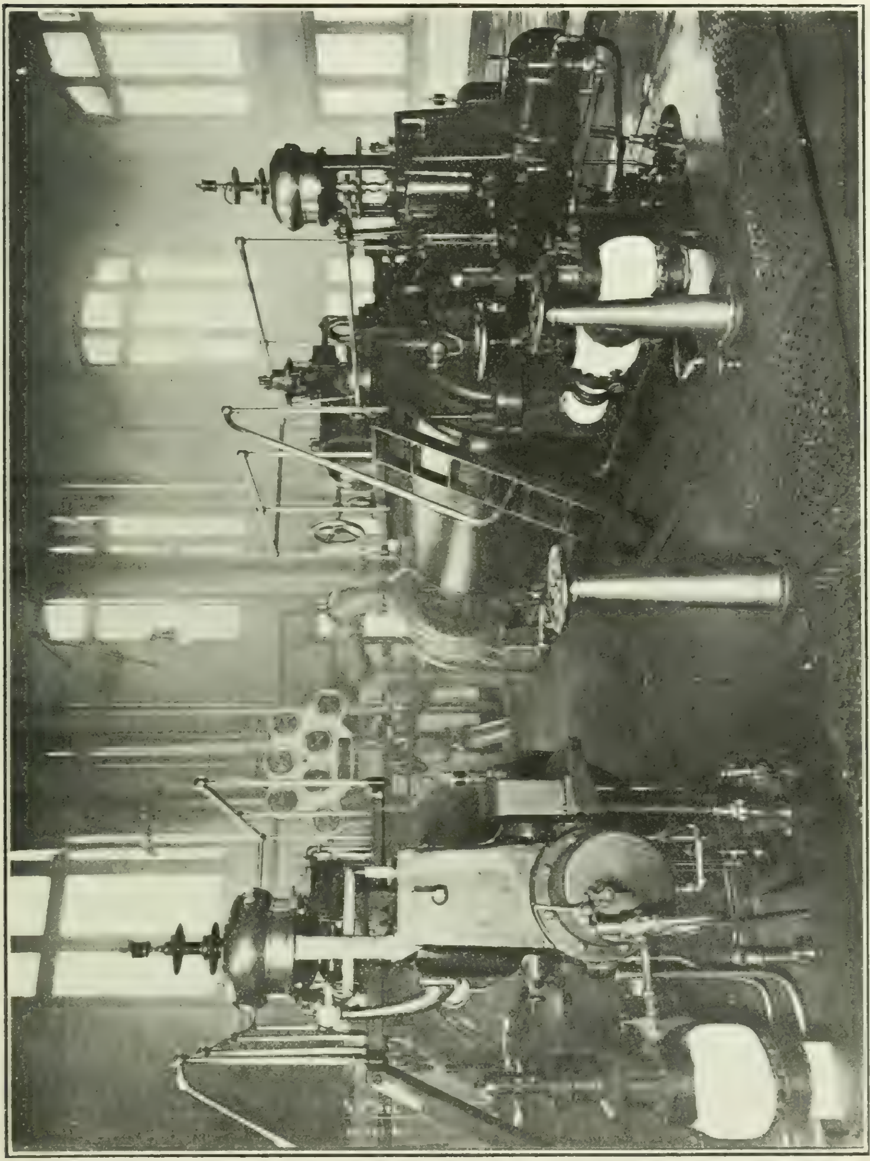
The only available site for a gas driven pumping plant was some 2000 feet distant from the Lake supply, the cost of connecting with which was practically prohibitive; consideration was next given to electrically driven pumps. It was decided that with only one company to obtain current from, the heavy standby charges asked and the cost of current made the proposition undesirable, more so as with only one source of supply, a failure of current would leave the plant useless. The steam turbine, direct connected to a turbine pump, located at the main pumping station, appeared to be the most satisfactory solution of the question and was finally determined on.


C-105.
CITY OF TORONTO.
HIGH PRESSURE FIRE SERVICE
PLAN SHEWING
GENERAL LOCATION OF MAINS & HYDRANTS.
SCALE 300 FT TO 1 IN
City Engineer
City Engineers Office,
Toronto March 18th 1909.
Main Pumping Station
George St.
Jarvis St.
Mutual St.
Dalhousie St.
Church St.
Bond St.
Victoria St.
Yonge St.
James St.
Albert St.
Terauley St.
Elizabeth St.
Chestnut St.
Osgoode St.
University Ave.
Simcoe St.
William St.
McCaul St.
St. Patrick Sq.
John St.
Beverley St.
Duchess St.
Duke St.
Shuter St.
Queen St. E.
Queen St. W.
Richmond St. E.
Richmond St. W.
Adelaide St. E.
Adelaide St. W.
King St. E.
King St. W.
Lombard St.
Court St.
Toronto St.
Temperance St.
Melinda St.
Jordan St.
Colborne St.
Wellington St. E.
Wellington St. W.
Leader Lane
W. Market St.
Front St. E.
Front St. W.
Esplanade St.
Scott St.
Bay St.
Sheppard St.
Pearl St.
Millstone Lane
Piper St.
Lorne St.
Harbour St.
Lake St.
York St.
York St. Bridge
Station St.
Emily St.
Nelson St.
Duncan St.
Dorset St.
Widmer St.
John St. Bridge
Toronto Harbour

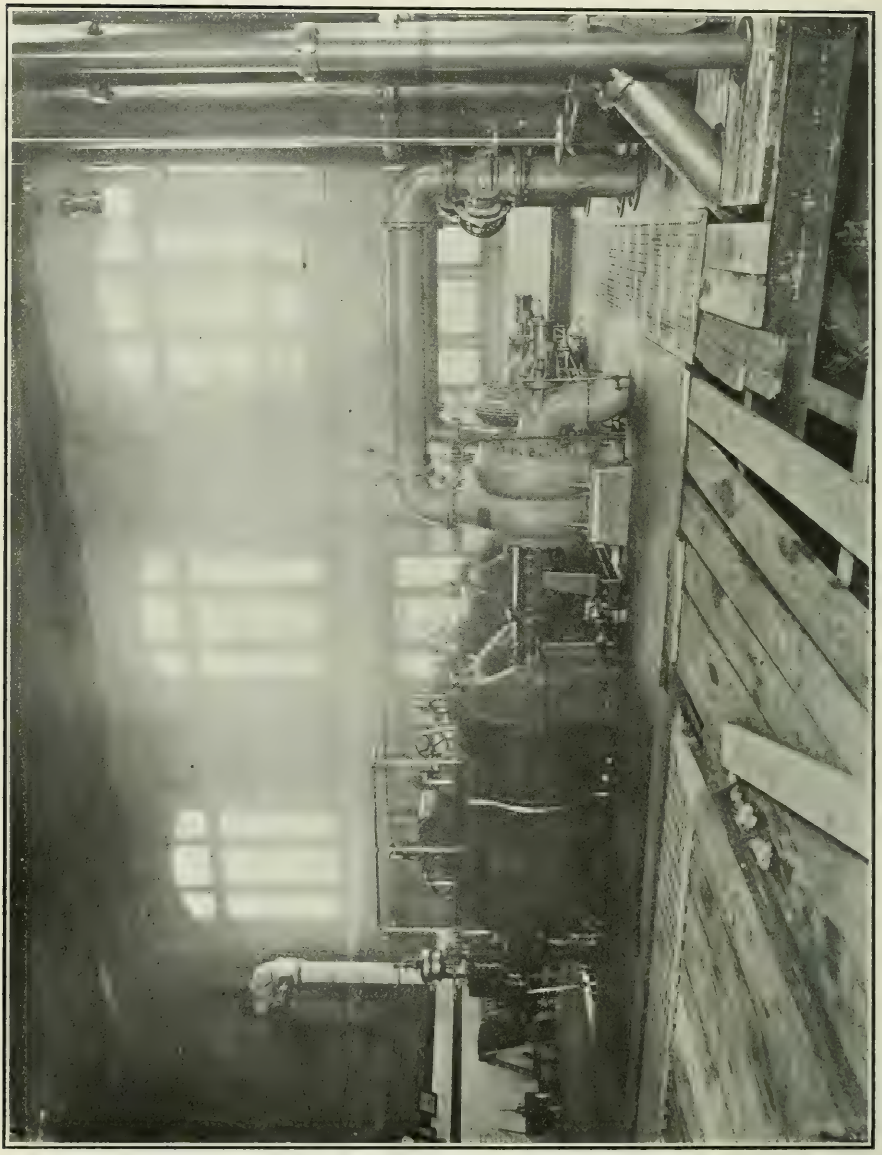
The engine house was built as an addition to the main pumping station, on the east side of same, as shown on block plan. Steam is obtained from the boilers supplying No. 6 Engine (a fifteen million triple expansion), the fifteen being cut out when it is found necessary to run both of the turbines.



The turbines are the Westinghouse-Parsons horizontal steam turbines of 1000 h.p. each, direct connected to two stage turbine pumps of the Worthington type; the condensers, which at first were of the jet type, did not work satisfactorily under the varying speeds and were changed to barometric condensers without circulating or dry vacuum pumps, the water supply being taken



TORONTO WATER WORKS. HIGH PRESSURE ENGINE ROOM AT THE MAIN PUMPING STATION AT THE FOOT OF JOHN STREET



TORONTO WATER WORKS. HIGH PRESSURE ENGINE ROOM AT THE MAIN PUMPING STATION AT THE FOOT OF JOHN STREET from the domestic pipes, the vacuum obtained being from 27 to 27½ inches. To start the plant but two valves have to be opened, viz., the throttle and the force injection, less than 40 seconds, bringing the plant up to speed and 300 pounds pressure.

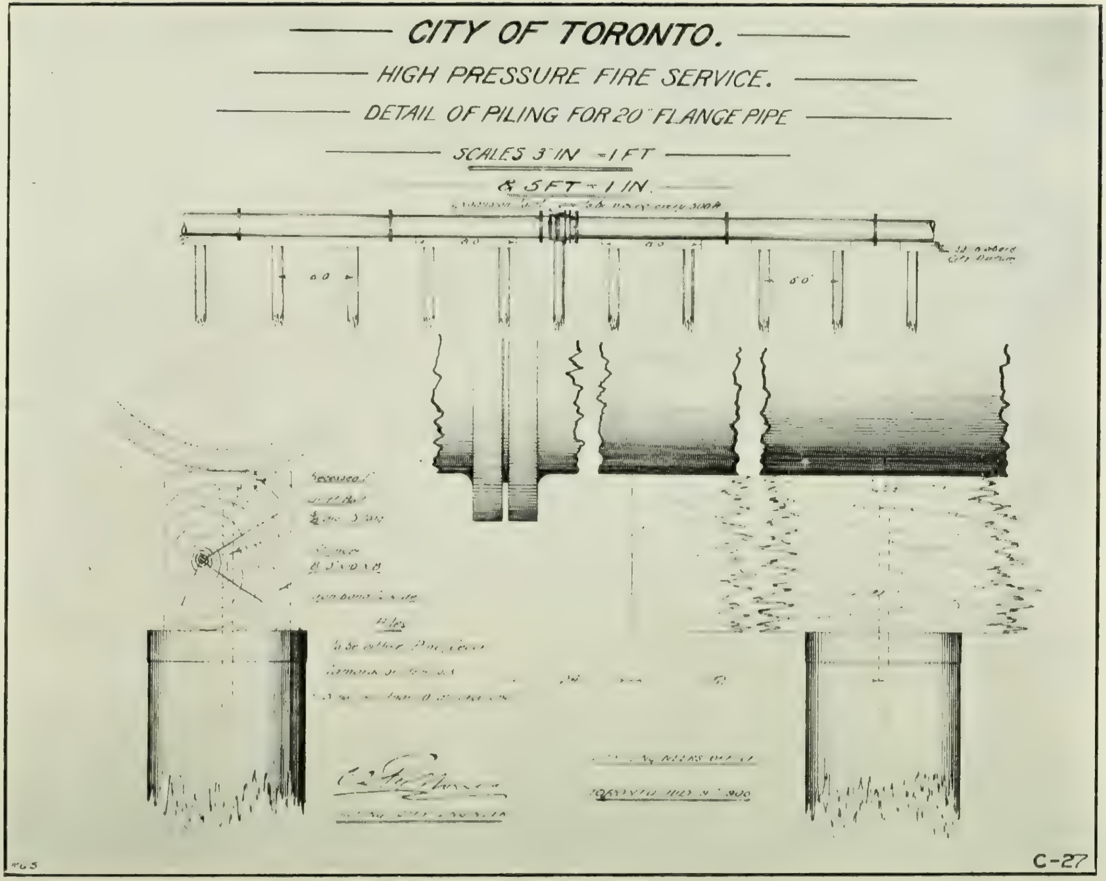
The capacity of the plant is twelve million United States gallons in 24 hours, divided into two units of six million each. It is proposed to increase this by two more units of six million each, probably electrically driven, as since the construction of the present plant, the Hydro-Electric Commission have entered into a contract to deliver current from Niagara Falls to the city, giving thereby two sources of power, viz., the above and the Toronto Electric Light Company. So far as the supply of water is concerned, the plant is very favorably situated, as a supply is available from any one of three sources: viz., first, from the bay by means of a 36 inch pipe; second, through the old 4 ft. conduit which supplied the domestic pumps, and third, through the present supply to the domestic pumps by way of the tunnel. Steam is supplied at 150 pounds pressure through six 250 h.p. water tube boilers and these are being augmented by the addition of 750 to 1000 h.p. more.

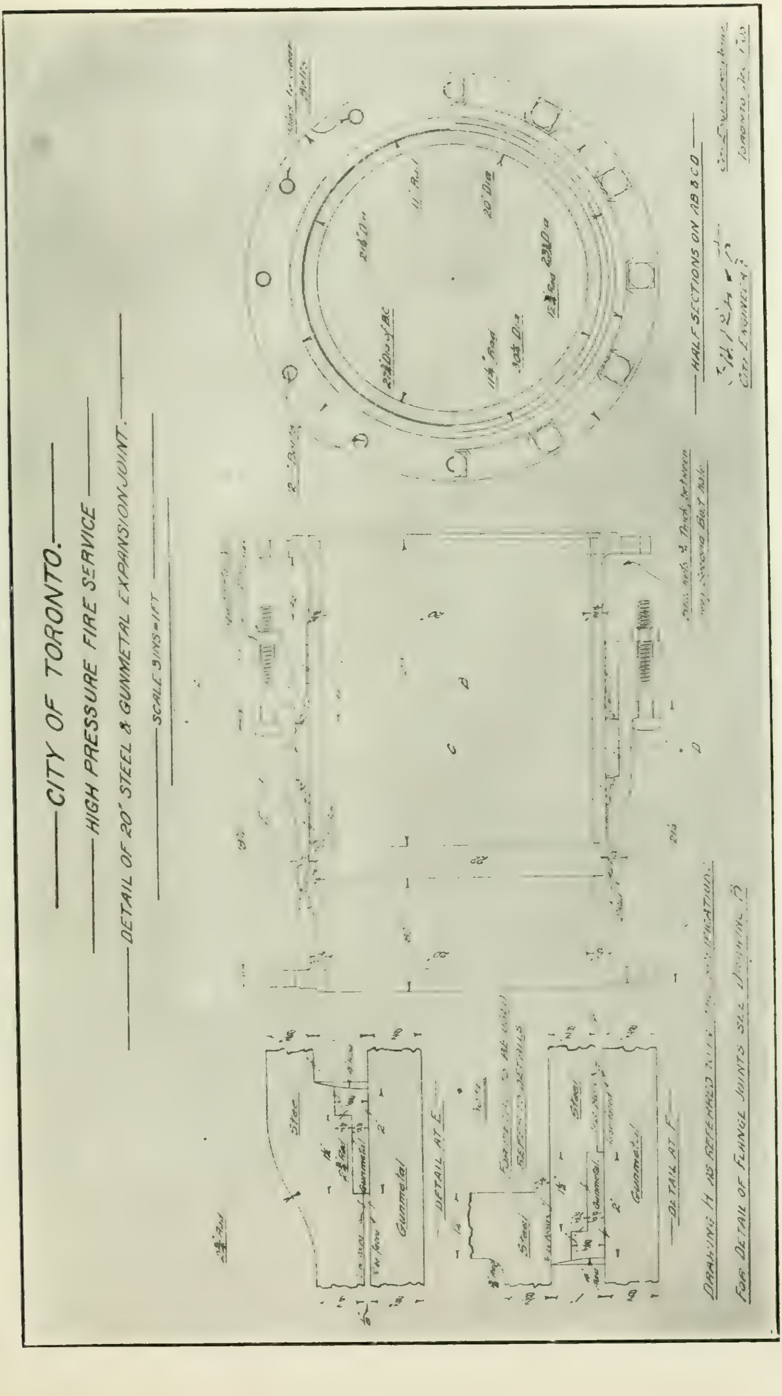
The pumps take their supply from a steel well running across the east end of the building, the average lift being 14 feet.

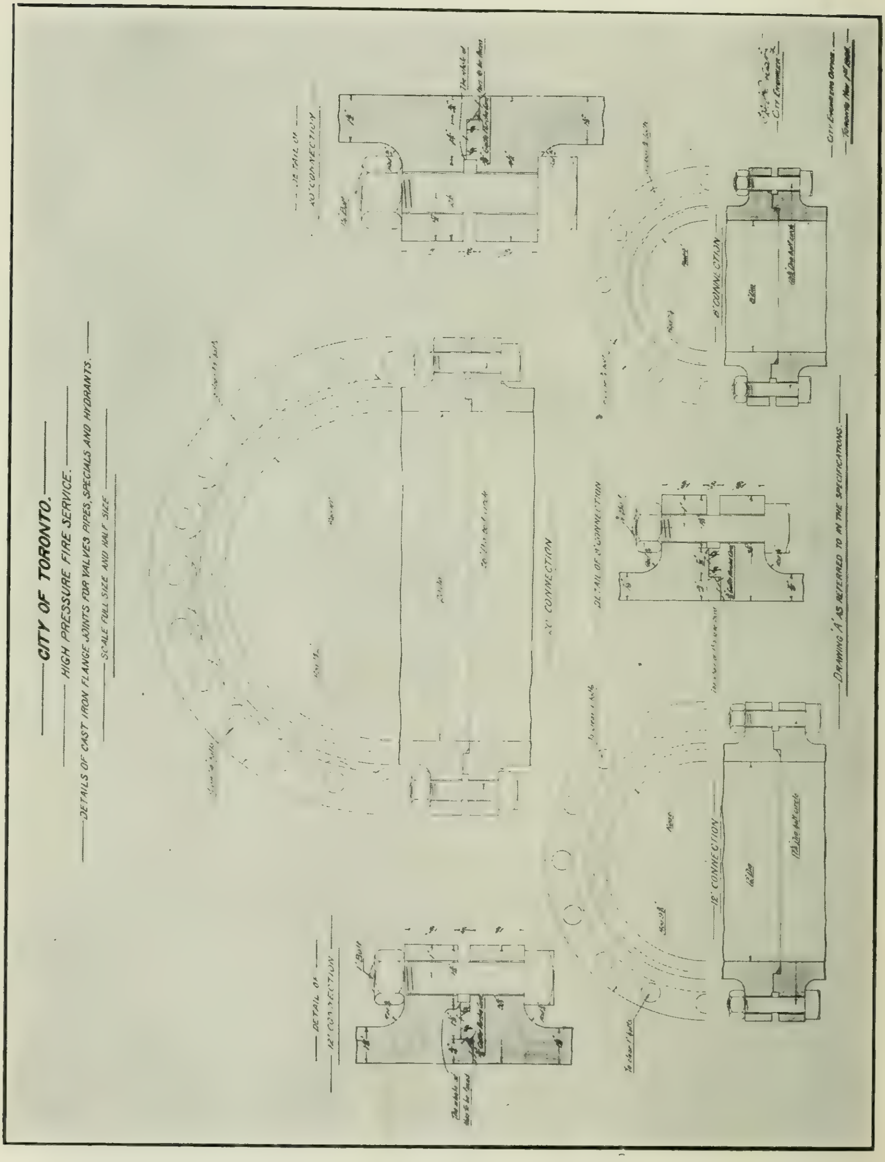
The plant is operated by the regular staff at the main pumping station with one additional man, making it extremely economical so far as maintenance is concerned. The simplicity of the operation, reliability, quickness with which it can be started makes it a very satisfactory fire fighting machine, and one that compares favorably with either gas or electric plants, so far as Toronto conditions are concerned. To put the entire plant under way does not take more than a minute as against seven for the Philadelphia plant. The speed of the pumps is 1500 revolutions per minute, while delivering six million gallons in 24 hours at 300 pounds pressure.

All the branches and discharge pipes in the engine house are of steel, including the casings of the pumps.

The suction pipes for the pumps are fourteen inches in diameter and the discharge pipes twelve inches, the latter discharging into a twenty inch flanged pipe leaving the engine house on the south side and carried south to the line of Lake Street, there turning east and running along the south side of


CITY OF TORONTO.
HIGH PRESSURE FIRE SERVICE.
DETAIL OF PILING FOR 20" FLANGE PIPE
SCALES 3" IN = 1 FT
& 5 FT = 1 IN.
8'0"
8'0"
8'0"
8'0"
Piles
C-27


CITY OF TORONTO.
HIGH PRESSURE FIRE SERVICE
DETAIL OF 20" STEEL & GUNMETAL EXPANSION JOINT.
SCALE 3 INS = 1 FT
HALF SECTIONS ON AB & CD
20" Dia
A
B
C
D
DETAIL AT E
DETAIL AT F
Steel
Gunmetal
Steel
Gunmetal
Steel
DRAWING H AS REFERRED TO IN SPECIFICATION
FOR DETAIL OF FLANGE JOINTS SEE DRAWING B
City Engineer


CITY OF TORONTO.
HIGH PRESSURE FIRE SERVICE.
DETAILS OF CAST IRON FLANGE JOINTS FOR VALVES PIPES, SPECIALS AND HYDRANTS.
SCALE FULL SIZE AND HALF SIZE
DETAIL OF 20" CONNECTION
20" CONNECTION
DETAIL OF 8" CONNECTION
8" CONNECTION
12" CONNECTION
DETAIL OF 12" CONNECTION
DRAWING 'A' AS REFERRED TO IN THE SPECIFICATIONS.
City Engineer
City Engineer's Office.
Toronto May 1st

Lake Street to Bay Street, up which it is carried to Queen Street. Owing to the fact that all the ground between the pumping station and a point a short distance north of the railway track on Bay Street, is land made by filling in, it was decided to pile it to the rock to give satisfactory support to the pipes. The manner of doing this is shown on the drawing of same. Expansion joints were inserted at distances of 500 feet along the entire length of iron flanged pipe. Attention is drawn to the joint of the flanged pipe which is made with a three-eighth gutta percha cord.

East and west of the twenty inch main on Bay Street twelve inch mains are taken off at nearly all street crossings and at the north and south street crossing of the twelve inch pipes, eight inch pipes are connected, all inter-sections being controlled by valves.

All specials throughout are of cast steel and all pipes from mains to hydrants are flanged steel pipe, each controlled by a valve.

At all high points air valves have been placed. The hydrants have three 3½ inch nozzles, a ten inch barrel and are similar in operation to those in use in Brooklyn, New York.

The spigot and socket pipes have double grooves and in laying have an eighth of an inch thick cardboard ring inserted between end of spigot and bottom of socket, to provide for any possible expansion or contraction. With the exception of the main along the Lake and part of Bay Street, all the rest are laid at a depth of eight feet from the surface to the axis of the pipe, no matter what size. The object attained being security from frost and less interference with existing pipes, drains, etc.

The average weight of—

	Per Ton
20″ spigot and socket pipe was 4065 lb. and cost	$30.84
20″ flanged pipe was 4076 lb. and cost	40.34
12″ flanged pipe was 1860 lb. and cost	30.72
8″ flanged pipe was 1005 lb. and cost	30.94

The minimum weight being respectively 3950, 1810, and 950 pounds.

Stop valves, 20″ cost	$184.00
12″ cost	70.00
8″ cost	30.45
8″ flanges	32.50
Hydrants, each	123.55
Expansion joints	345.08

The steam turbines and turbine pumps, including valves and all piping in engine room	$69,000.00
Travelers	2,200.00
Building, including Foundation	36,000.00
Steel well	1,950.00
Pipelaying, valves, hydrants, concrete buttresses, valve and air chambers, repairs and alterations to existing pipes, repairs to permanent pavements	124,924.00

The average cost of steel specials was $7\frac{4}{10}$c per pound.

The guaranteed consumption of steam was 16.7 pounds when pumping six million at 300 pounds pressure and twenty-three pounds when pumping same quantity at 150 pounds pressure per square inch. The turbine to be capable of taking care of an overload equal to $1\frac{1}{4}$ times full load.

The total weight of turbine and pump about 80,000 pounds.

The length over all 25 feet with a width of 5 feet 3 inches and a height above the floor level of 8 feet 4 inches.

A test of the plant was made under the direction of the engineer of the Fire Underwriters' Association at which eight 2 inch streams and one $1\frac{1}{4}$ inch stream were thrown. The pressure at the hydrant dropping as streams were put on from 300 to 182 when the eight 2 inch and $1\frac{1}{4}$ inch were playing.

WATER PROBLEMS OF MEXICO[1]

EDWARD BARTOW.

The water problems of Mexico may be considered under four divisions; irrigation, drainage, sewage disposal, and the water supply proper.

The solution of these problems, especially of irrigation, drainage and water supply, have occupied the attention of the inhabitants from very early times. Before Jamestown was settled the Spaniards in Mexico began the constructon of aqueducts. In 1607, the very year in which the English landed in Virginia, they began the construction of the Nochistongo, an immense ditch, designed to drain the valley in which the City of Mexico is situated. They also constructed irrigation reservoirs and ditches in the arid parts of the country.

Entering Mexico from the north one is impressed by the immense stretches of desert dotted, here and there by fertile spots on which are grown corn, sugar cane, etc., and where cattle and sheep are raised. In the illustration (Fig. 1) are shown arid plains and mountains. At the foot of the mountains is a spot where irrigation allows the growth of trees, the cultivation of the fields, and the raising of a herd of cattle. The irrigation problems of Mexico are similar to those which are being considered by the reclamation service of the United States, and there are similar possibilities of future development of the waste lands.

As we approach the City of Mexico, other more lofty mountains, whose summits are covered with snow the year round, come into view. The melting snow from these mountains serves as a source of water for the lakes in the valley and furnishes an abundant and inexhaustable supply of water to the under-

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[1] This paper was presented at the Washington convention, 1908, but was not printed with the proceedings of that convention owing to the mislaying of the MS.—SECRETARY.]

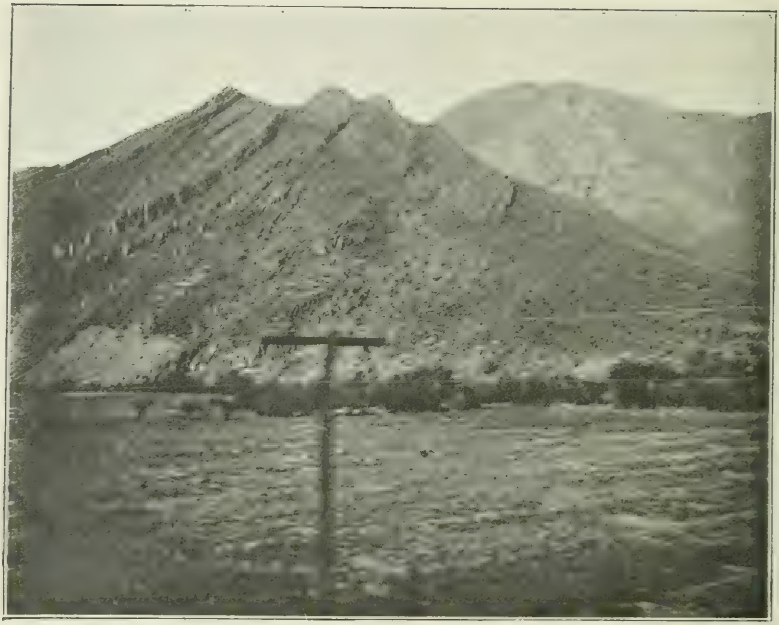

FIG 1. ARID PLAINS AND MOUNTAINS AND IRRIGATED RANCH IN NORTHERN MEXICO.

lying strata of the valley of Mexico. Mounts Popocatapetl[2] (Fig. 2), and Ixtaccihautl, are the most prominent peaks. They rise to a height of about 18,000 feet above the sea level and about 10,000 feet above the City of Mexico. The city is thus located on a plateau at an elevation of 8000 feet above the sea. The plateau is really a valley as it is entirely surrounded by hills and mountains. There is no outlet for surplus water. The valley of Mexico is located in the Torrid Zone and evaporation is considerable, yet this is not sufficient to equalize the water levels at all times. For this reason great trouble has been experienced from inundations. There are reports of such inundations even before the arrival of the Spaniards. In 1510, nine years before Cortez entered the City of Mexico, a great tidal wave is said to have swept over the country. The effects of this rise in the water had not disappeared when Cortez entered the country and he was obliged to pass over causeways to the site of the present City of Mexico.

The situation will be better understood if it is borne in mind that the water which falls into the valley, together with the melted snow from the mountains is ultimately collected in four large lakes. Evaporation has left in the lower of these lakes a brackish water unfit for drinking purposes. In wet seasons the lakes naturally became greatly increased in size and caused floods of greater or lesser degree in the City of Mexico. Between and around the upper lakes are swamps. These are inhabited by Indians and are called the floating gardens of Mexico. In these gardens are Indians who are practically independent of the Mexican Government, and who live in a very primitive way. At the present day these gardens furnish the greater part of the supply of vegetables for the City of Mexico. They are connected directly with the city by canals and it is possible to journey for days upon the main canals and on the smaller ones branching through the gardens. The illustrations (Figs. 3 and 4) show views in the floating gardens near Xochimilco.

The first inundation after the Spanish occupation occurred in 1552. This led to the first precautionary measures to prevent a recurrence. A dike was constructed to try to keep the water

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[2] Figs. 2, 5, 6, 7, 8, 9, 11, 12, 13 and 14 are from copyrighted photographs by Waite, and are reproduced here by permission. All rights are reserved.

FIG. 2. MOUNT POPOCATEPETL, MEXICO.

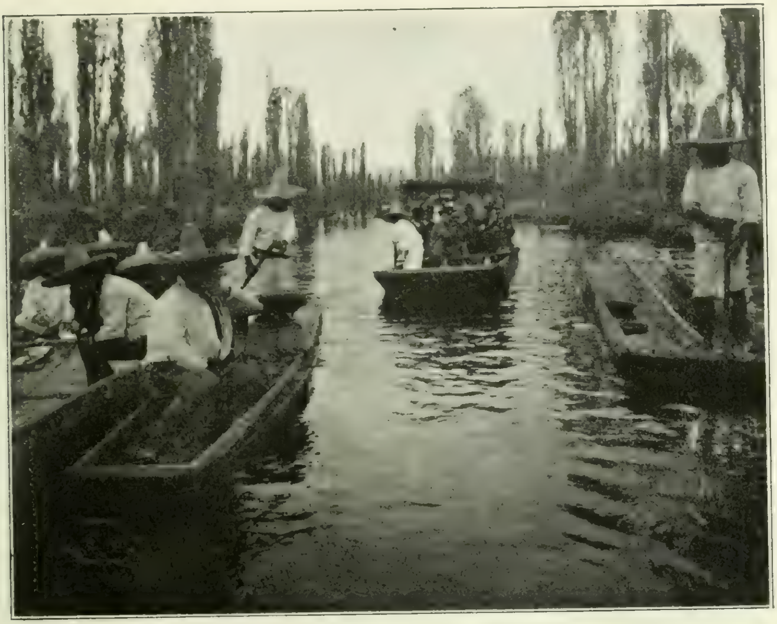


FIG. 3. FLOATING GARDENS OF MEXICO NEAR XOCHIMILCO.

FIG. 4. FLOATING GARDENS OF MEXICO NEAR XOCHIMILCO.

out of the city. This was not efficient. In 1607 the so-called Nochistongo or drainage canal was begun. This was ten miles long including a long tunnel under one of the lowest hills. It was expected to remove the surplus waters. At the time of the next great inundation, in 1629, the tunnel caved in. This was due to the fact that the roof was supported only by lagging, insufficient funds having been appropriated for the engineers to properly construct the tunnel. It was then decided to turn the tunnel into a ditch by digging down from the surface. This ditch, in places 300 feet deep, was completed in 1789. Along this excavation one of the great railroads now enters the City of Mexico. The present condition of the ditch is seen in the illustration (Fig. 5). The bottom of this ditch was still 30 feet above the mean level of the lowest lake, and parts of the valley having a level lower than the bottom of the ditch were still frequently flooded.

In 1856 another drainage ditch was begun. This ditch is 20 miles long and includes a tunnel six miles long. It was completed in 1896 at a cost of $13,000,000. There are suitable gates to regulate the flow and to maintain a constant level in the lakes. The outlet of the tunnel is shown in the illustration (Fig. 6) and an idea is given of the solid construction of this new drainage ditch. It is certainly an excellent piece of engineering.

A complete sewerage system is being constructed in the City of Mexico and all the sewage of the city is to be collected in a main sewer which empties into the new drainage ditch. By this means the sewage is removed from the valley, affording a very satisfactory solution to the sewage disposal problem of the city. Arrangements are made so that at times of high water the sewage can be pumped and any backing up of the waters is prevented. It is interesting to note that the pumping is done by electricity furnished from the water falls which surround the valley, and which also furnish the power for electric railways and all other electrical purposes. It is planned to use the water from the new drainage ditch to generate electrical energy.

The water supply of the City of Mexico came originally from springs. Aqueducts were constructed and were used by the Aztecs before the arrival of the Spaniards. The first aqueduct built by the Spaniards to the City of Mexico was begun in 1603 and finished in 1620, the year the Pilgrims landed at Plymouth

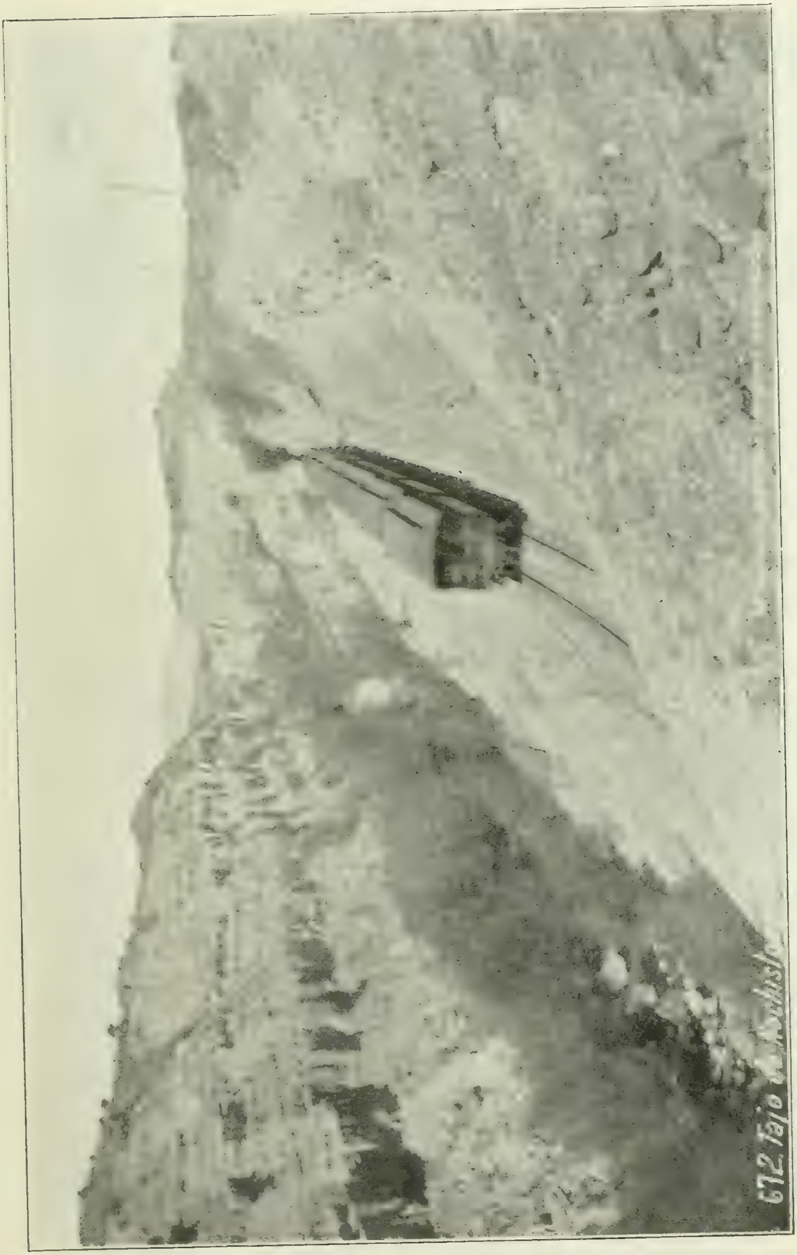


FIG. 5. THE NOCHISTONGO, THE GREAT DRAINAGE DITCH OF MEXICO.

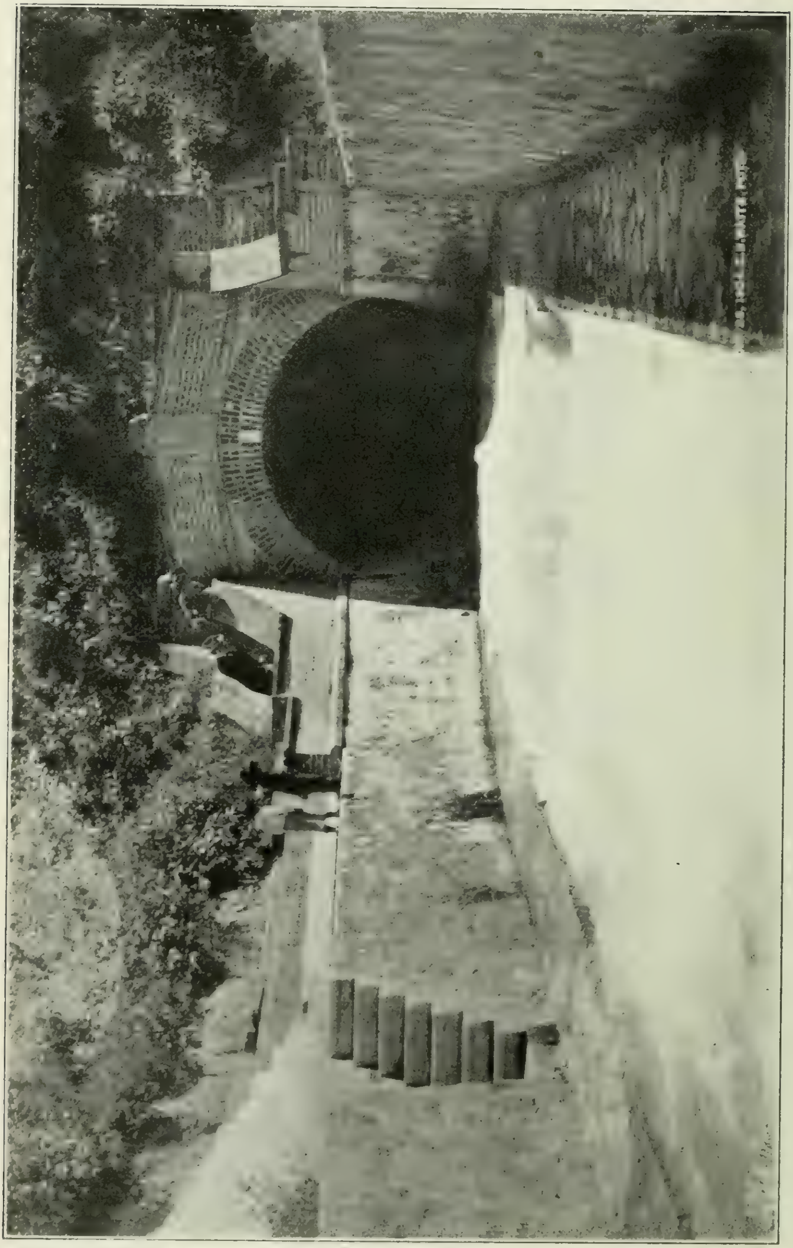


FIG. 6. OUTLET OF THE NEW DRAINAGE TUNNEL OF THE CITY OF MEXICO.

Rock. This brought the water from the springs at Chapultepec and gave an adequate supply of water at that time. Later aqueducts were built from springs at Tacubayo (Fig. 7), and from Guadalupe (Fig. 8). The latter is nine miles long and is still in use. Other aqueducts were built to supply other cities. The traveler notices especially the aqueducts at Guanajuato and at Queretero. The latter is more than six miles long and has supplied the city of Queretero for more than a century.

In these aqueducts the water flowed through an open channel above the arches. The channel is readily seen in the picture of the aqueduct from Tacubayo (Fig. 7), where the broken end of the aqueduct shows the open ditch at the top. The water carried by these aqueducts flowed into open basins placed in different parts of the cities, to which the people must go for their water. These basins were sometimes made very ornate, like the fountain along the aqueduct from Chapultepec (Fig. 9), or are very simple, like the basin at Puebla, Mexico (Fig. 10).

The water is taken to the houses by the people themselves (Fig. 10) or by professional water carriers (Figs. 11 to 14). The method of transporting the water from the basins to the homes differs in the different Mexican cities. The illustrations show characteristic methods in use in various cities. Fig. 11 shows a water carrier in the City of Mexico, Fig. 12 in Guanajuato, Fig. 13 in Queretero. Figs. 10 and 14 show methods that we may run across almost anywhere in the country.

This method of supplying the City of Mexico from springs has proven inadequate. The flow through the open aqueducts, the exposure of the water in the open fountains, and the delivery by means of water carriers through the streets, has not furnished a very pure supply. The increase in the number of bacteria between the spring and the home is very large. Thousands of bacteria have been found in the delivered water. Stone filters are used in the hotels and the better residences, but these are not available to the general public.

With the general improvement in drainage and sewerage of the city, there is also an improvement in the water supply. The valley of Mexico since it is surrounded by hills and mountains forms a wonderful artesian basin. There are over 1,000 private artesian wells in the City of Mexico, itself. Yet, to obtain a sufficient general supply of pure artesian water a new aqueduct

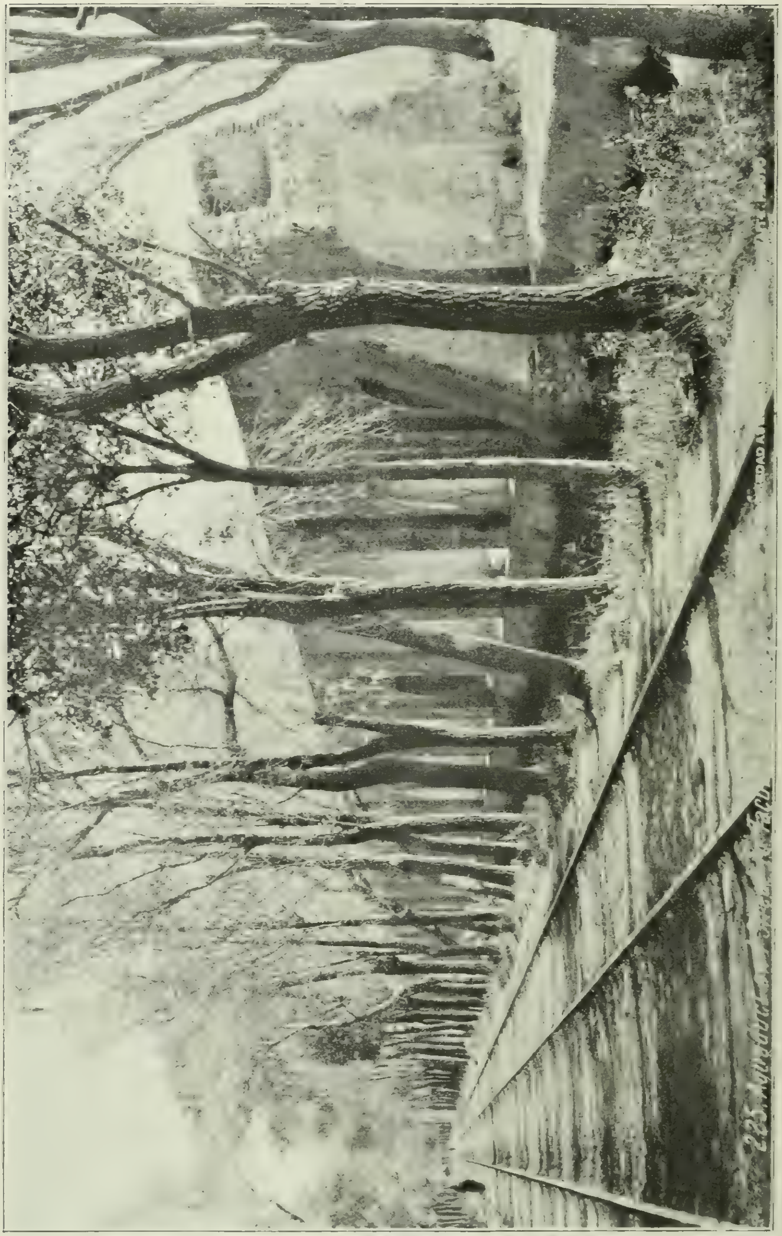


FIG. 7. AQUEDUCT FROM TACUBAYO TO THE CITY OF MEXICO.

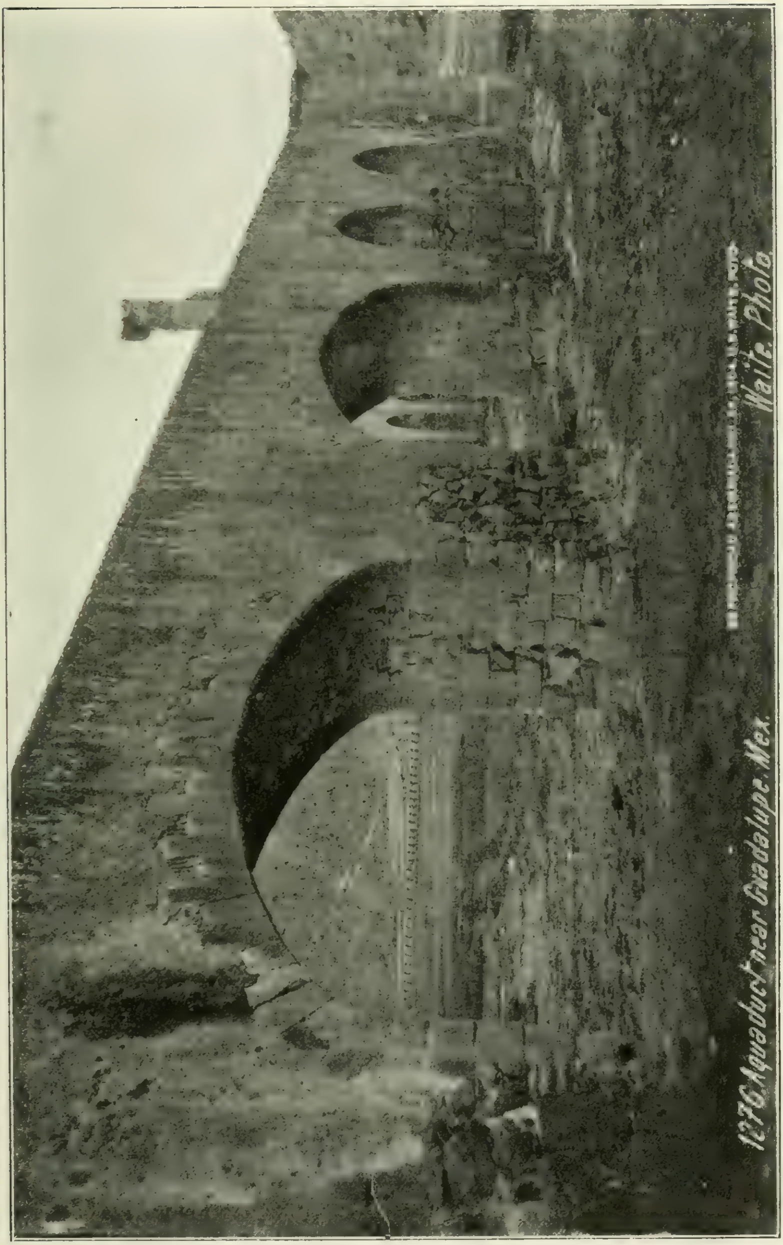


FIG. 8. AQUEDUCT NEAR GUADALOUPE, MEXICO.

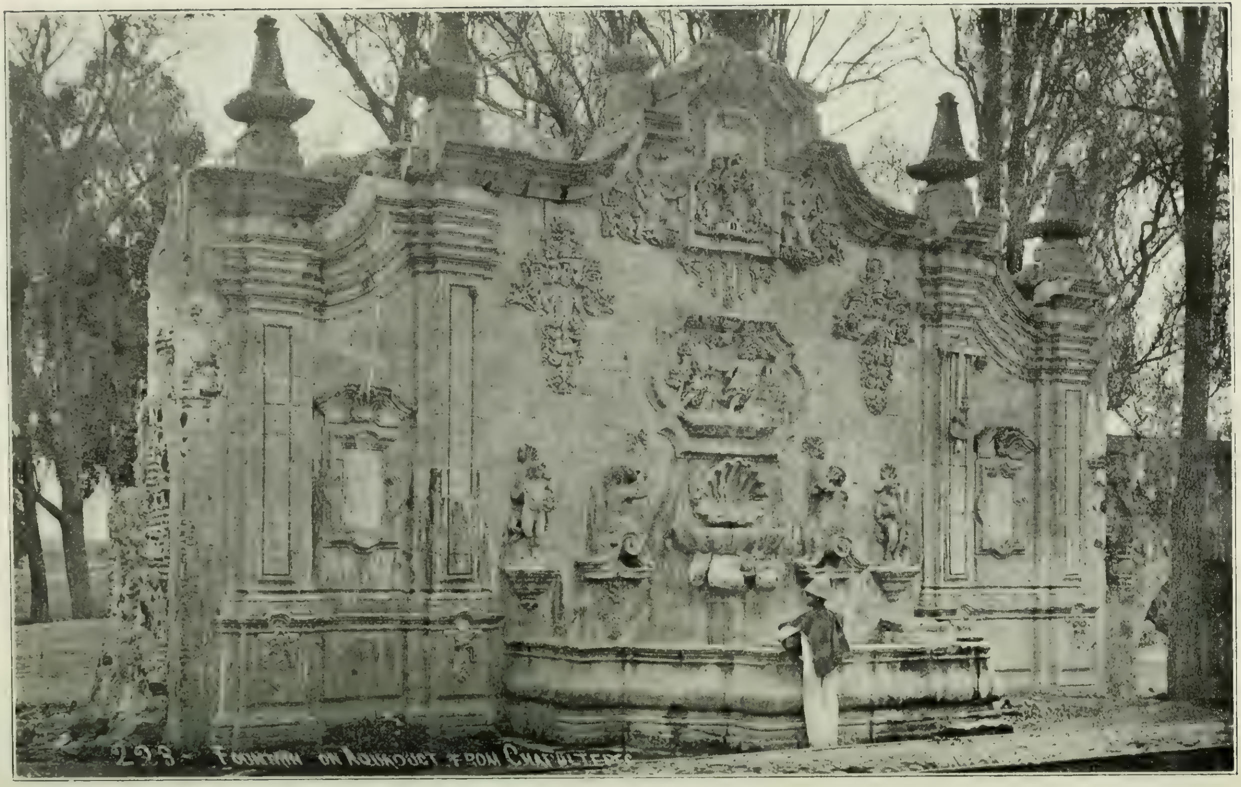


FIG 9. FOUNTAIN ON AQUEDUCT FROM CHAPULTEPEC TO THE CITY OF MEXICO.

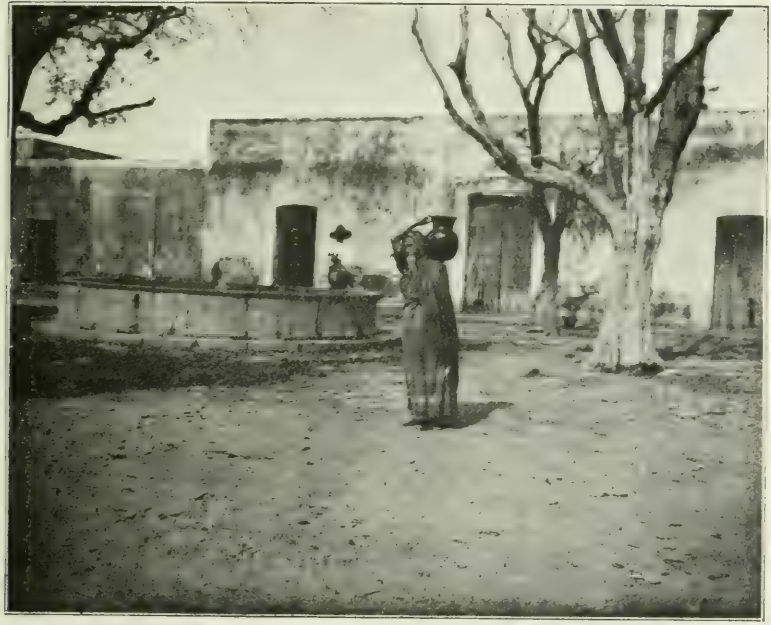


FIG. 10. FOUNTAIN AND WATER CARRIER, PUEBLA, MEXICO.

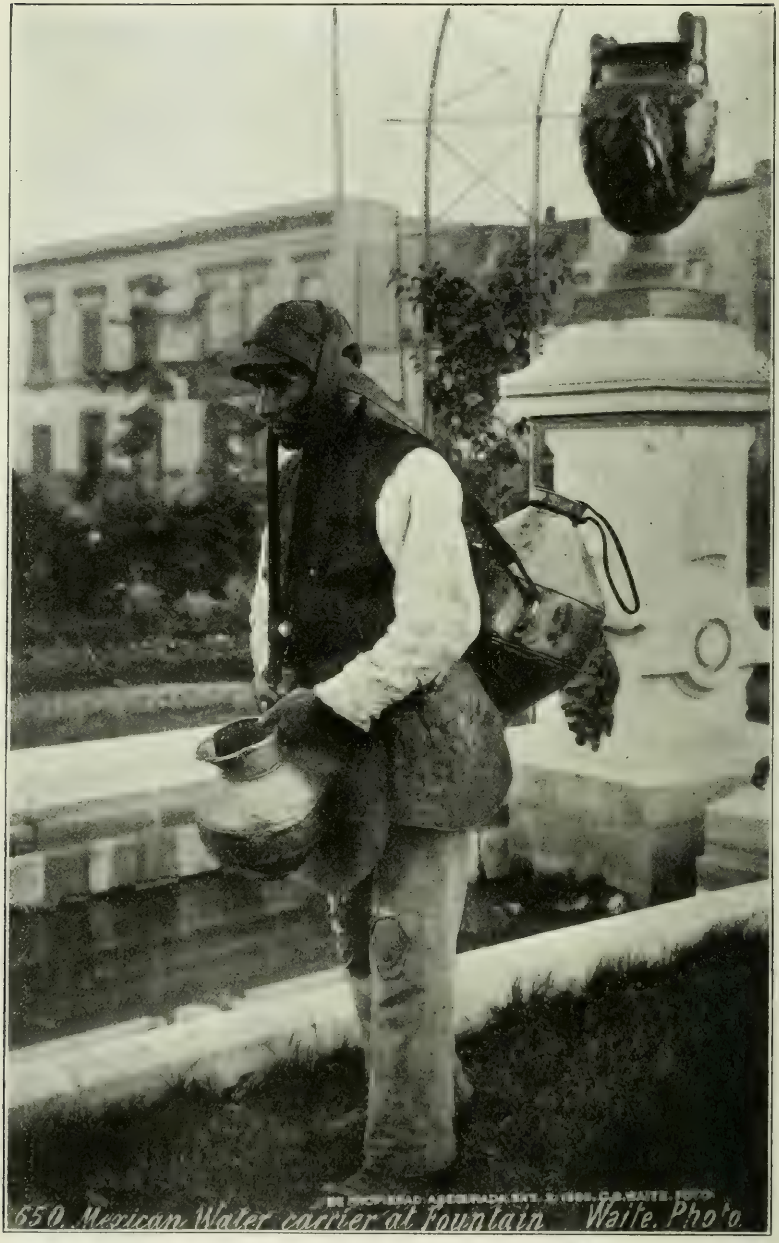

650. Mexican Water carrier at Fountain
Waite. Photo.

FIG. 11. WATER CARRIER, CITY OF MEXICO.

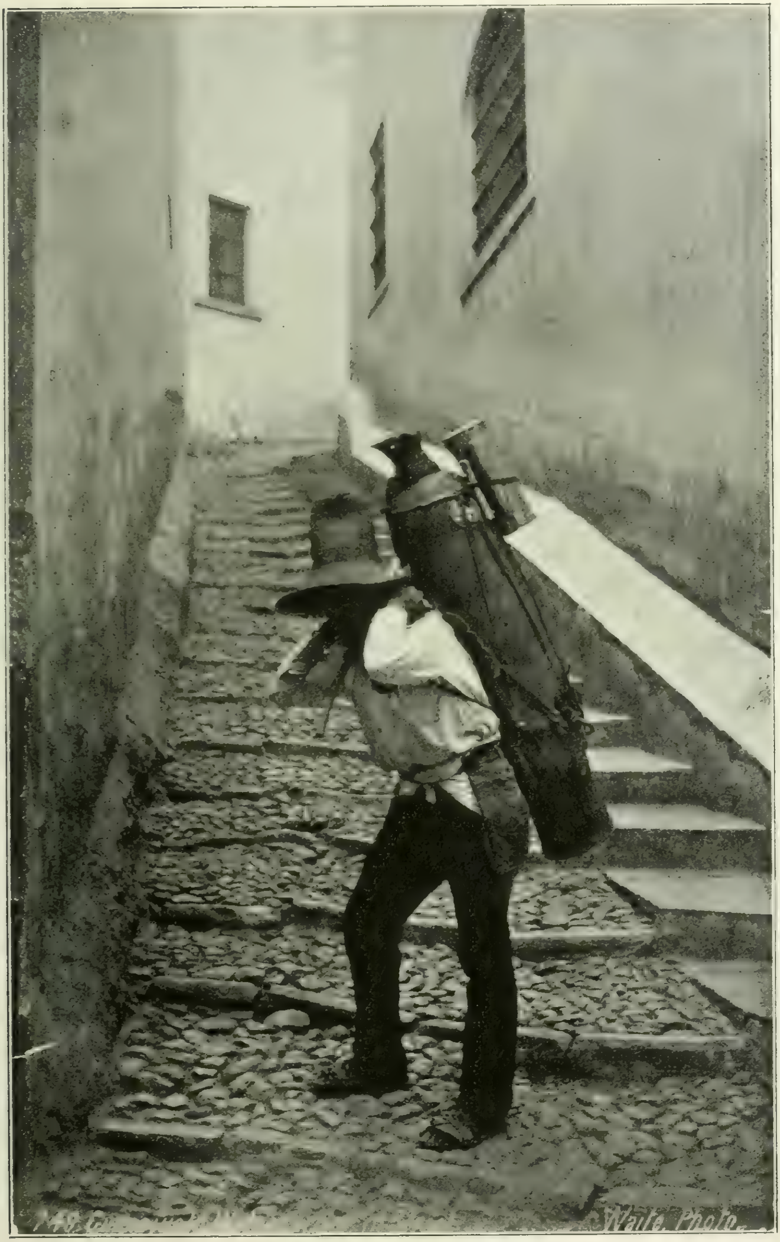

Waite, Photo.

FIG. 12. WATER CARRIER, GUANAJUATO, MEXICO.

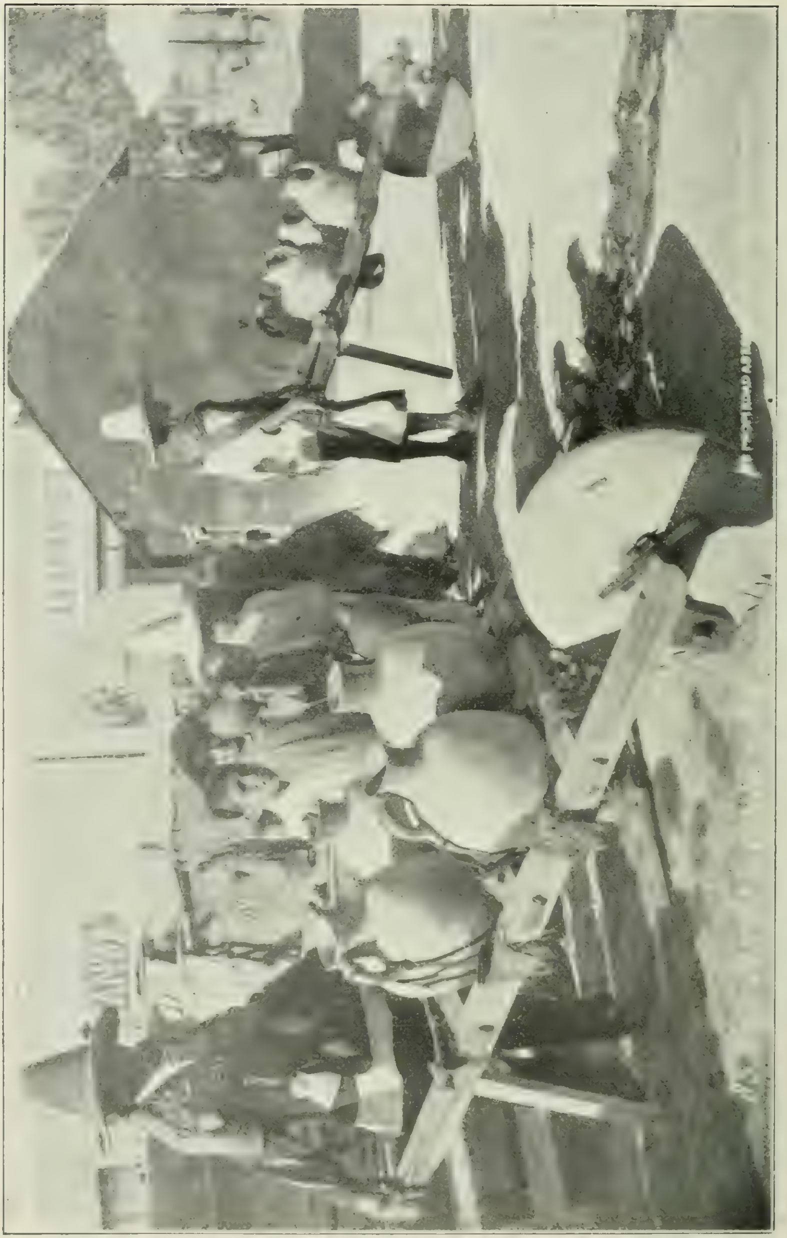


FIG. 13. WATER BARROWS AT QUERETERO, MEXICO.

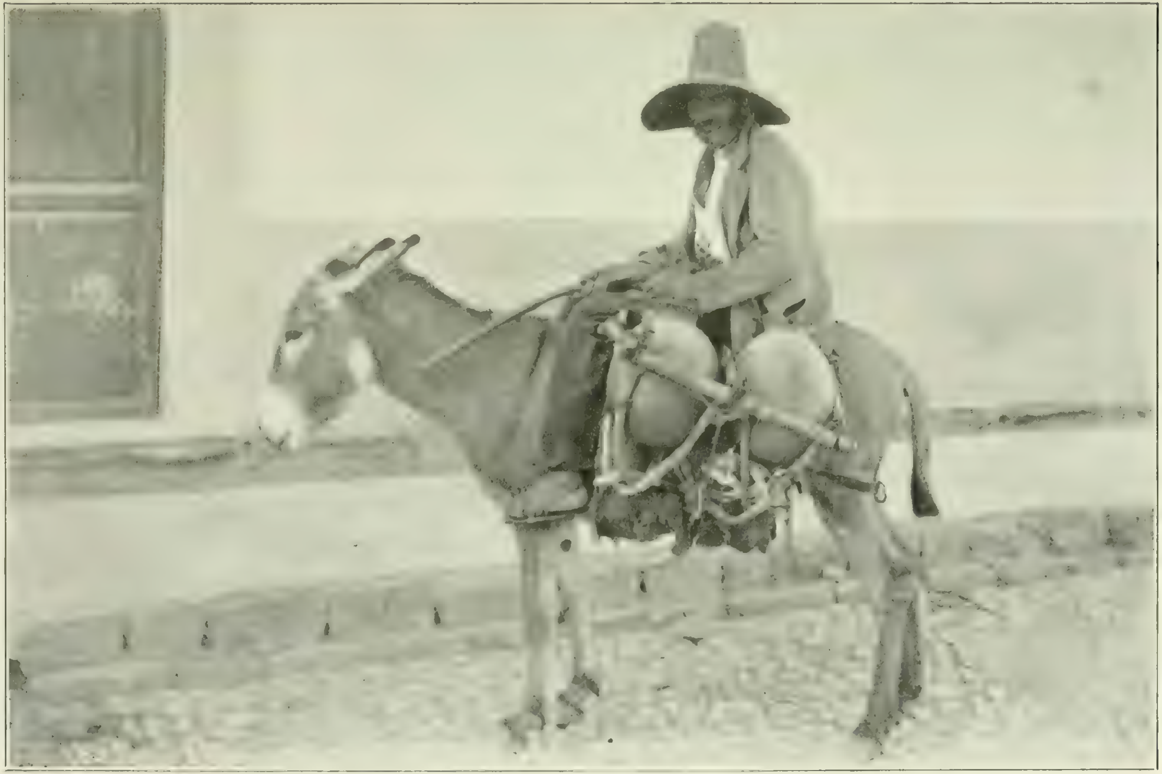


FIG. 11. MEXICAN WATER CARRIER.

25 miles long has been constructed to bring water from artesian wells at Xochimilco (Fig. 15). Here is located one of the finest wells in the world. The one well has a flow of 15,000,000 gallons per 24 hours. This with other projected wells will furnish an abundant supply of pure water.

The aqueduct to carry this water to the City of Mexico is modern in every particular. It is built of reënforced concrete (Fig. 16) with open towers (Fig. 17) at intervals to reduce the pressure. It is interesting to note that the excavation for this aqueduct has been made by methods in use when the Nochistongo was excavated. All of the dirt and stones were carried from the ditch on the backs of the peons. This labor is so cheap, it was stated, that the excavation could be made more cheaply in this way than by the modern machinery used in the United States. There were used, however, modern concrete mixers, four of which can be seen in operation in the illustration (Fig. 16).

The distribution of the water through pipes to the houses is becoming more and more common, and the open fountains are disappearing. This, as well as progress along the other lines referred to, illustrates the improvement being made in the whole country of Mexico, for this improvement is not confined to the City of Mexico. The great Esperanza dam at Guanajuato is a feat of engineering comparable with work in other countries.

These special improvements as well as reforms in the method of government, in public health measures and in other things conducive to the general welfare are due in a great measure to President Diaz, who may well be called the "Grand Old Man of Mexico."

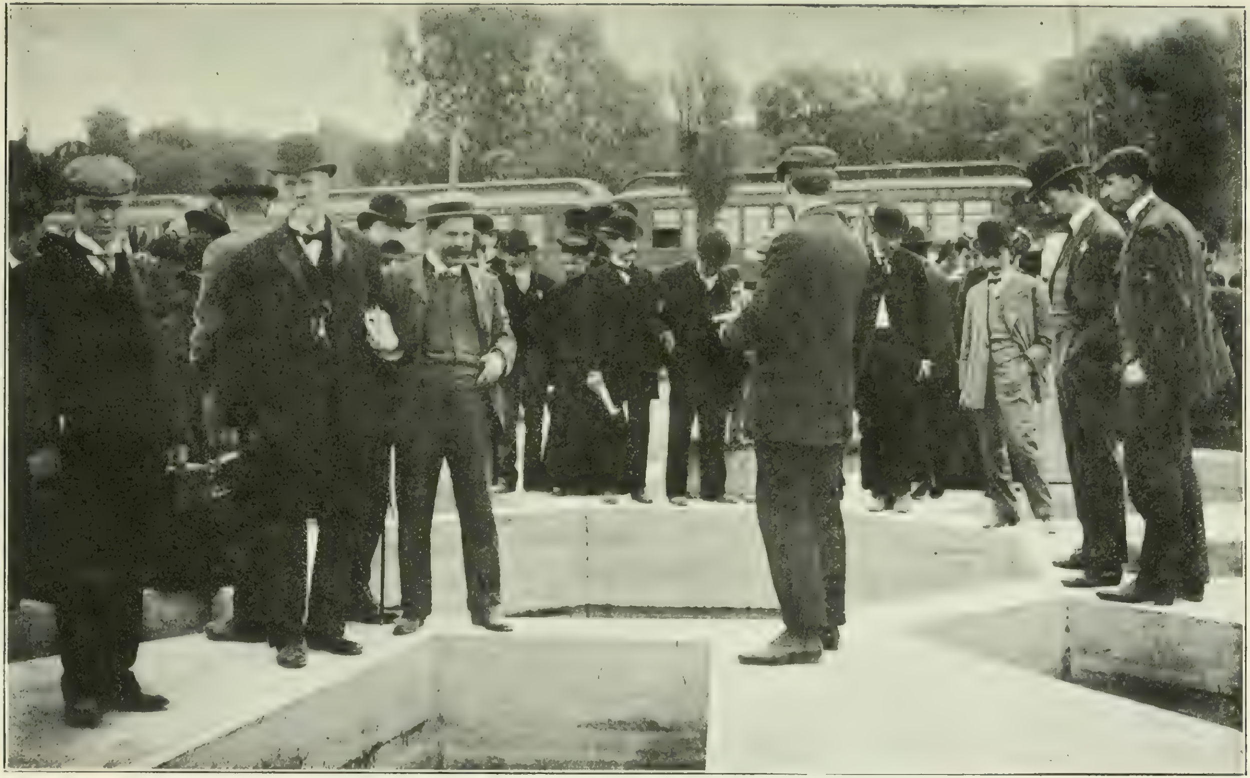


FIG. 15. ARTESIAN WELL FOR NEW WATER SUPPLY, CITY OF MEXICO.

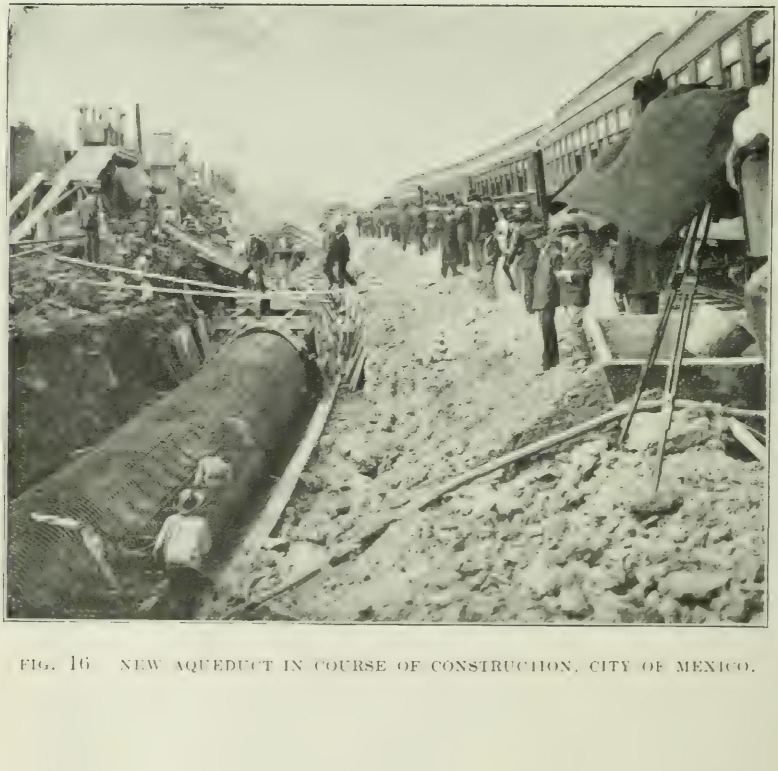


FIG. 16. NEW AQUEDUCT IN COURSE OF CONSTRUCTION, CITY OF MEXICO.

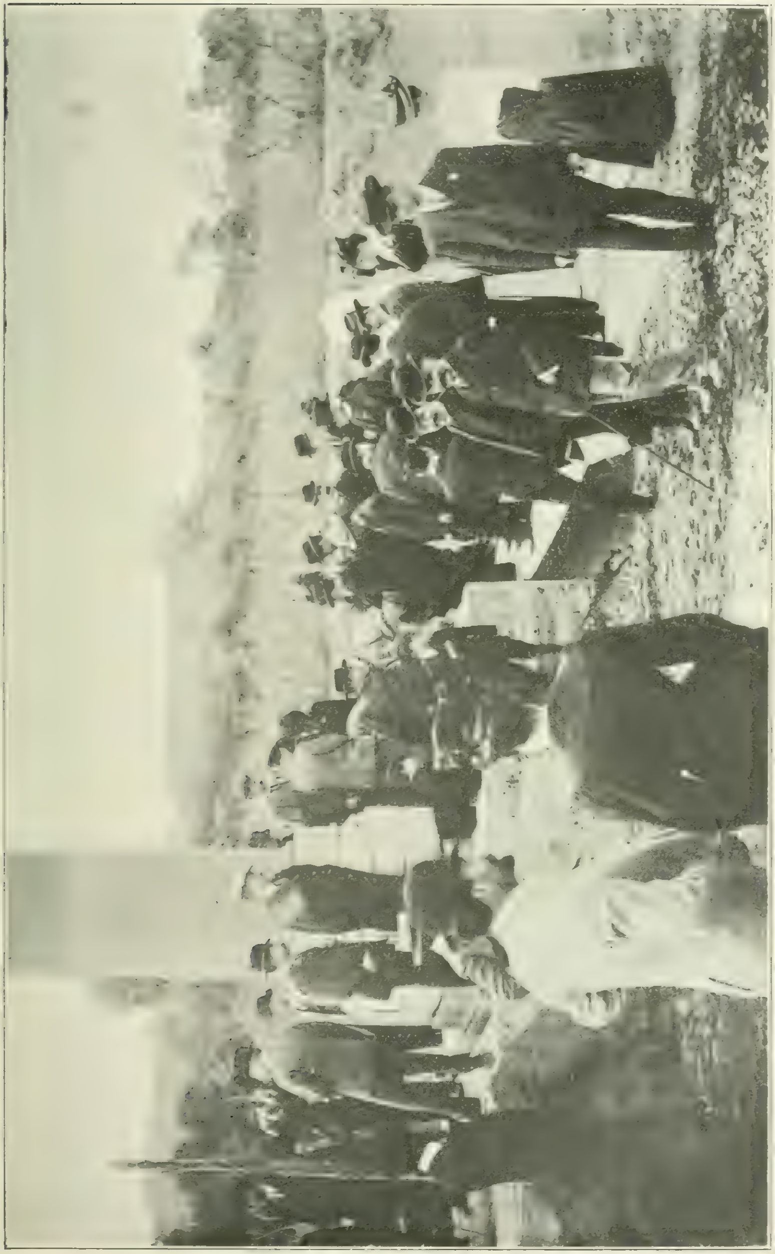


FIG. 17. HOLLOW COLUMNS ON NEW AQUEDUCT TO RELIEVE PRESSURE, CITY OF MEXICO.

AN ATTEMPT TO ANNUL A PERPETUAL CHARTER

JAMES R. FITZPATRICK

The Grand Rapids Hydraulic Company was given a perpetual charter by a special act of the legislature of Michigan passed in 1849. The company was compelled by its charter to furnish a pure supply of water, and preparations were made immediately to furnish a water supply for the then village of Grand Rapids. This was the only water supply for the city until the early 70's when the municipal plant was installed.

The first legal battle between the city and the Hydraulic Company was begun in 1886, when the city undertook through court proceedings to stop the Hydraulic Company from furnishing water. This case was decided by the Michigan Supreme Court in favor of the Hydraulic Company. In the opinion given by Mr. Justice Campbell, he referred to the poor quality of the water furnished by the city, and the excellent quality furnished by the Hydraulic Company, and stated that if the Hydraulic Company

> is required to quit business the results will be disastrous to private health and comforts now, whatever they may be in the future.

The opinion also specifically stated that competition was a good thing for the city.

In 1904 the next clash between the city and the company was begun. The city water supply was taken from the Grand river, and was constantly under fire of criticism. Various administrations had suggested or endeavored to secure a better supply for the municipal plant of Grand Rapids. Bailey Springs, about five miles north of the city, which is credited by the government geologists with a daily supply of seven million gallons, but which is really much larger, was sought by the city as a supply. No official step had been taken, the then mayor simply having the proposition in abeyance. While the city was thinking about buying Bailey Springs, the Hydraulic Company stepped in and bought it. This proved to be the last straw, as was evidenced when the Michigan state legislature met early in 1905. The mayor of the city recommended to the common council in March, 1905, that the legislature be asked to repeal the Hydraulic Company's charter. The loop-hole through which this could be done was a reserved power clause contained in the company's charter which says:

> The legislature may at any time hereafter amend or repeal this act.

The common council accepted the mayor's recommendation, and on March 28, 1905, the proposed bill was introduced in the legislature. The following day, all rules were suspended and the bill was passed in the lower house. The bill was immediately taken to the senate, all rules suspended and the bill was passed in the senate, making two days practically to repeal a charter of sixty years' standing. No hearing was granted by any committee of either house to the Hydraulic Company, although a hearing was demanded of the representatives who fostered the bill in the legislature, the day it was introduced. The only hearing was granted by the governor to the representatives of the company on April 5, 1905. The governor signed the bill that same day, making the repeal to the company's charter a law. Immediately following, somebody in the legislature discovered that a parliamentary law had been violated in some manner, and it was necessary to pass the bill over again, so that on April 12 it was introduced in the senate, all rules were suspended and the bill passed. The following day it went through the same procedure in the lower house, and was passed again. The second bill, which was the identical bill passed on March 28 and 29, became a law on the twenty-fifth day of April. No notice of the contemplated reintroduction and re-passing of the bill was given the Hydraulic Company. The bill passed by the legislature provided a method of compensation for the Hydraulic Company. It gave the company until November 1, 1906, to get out of business, and also afforded the company the same time to file a claim for the value of its tangible property, nothing to be allowed for the franchise or goodwill. Under these conditions the tangible property would include a complete pumping station, distribution system and standpipe, together with a large quantity of real estate, none of which could be used by the Hydraulic Company for the purposes originally intended. The value of such tangible property would be simply junk value, and evidently was so considered by the city, some of whose officials were quoted as having placed a value of $75,000 on the entire outfit.

In accordance with the terms of the bill the Hydraulic Company filed a claim with the city for the value of its plant. This claim was for something over $900,000, and was referred to a committee, where it is probably safely resting.

A short time after, the ouster proceedings in the nature of quo warranto were begun by the people of the state of Michigan, by the attorney general at the relation of the mayor, city attorney and general manager of the Board of Public Works of the city of Grand Rapids. These proceedings were brought in the Kent County Circuit Court. When the case finally reached trial the city demurred to the company's answer, and the demurrer was sustained by the Circuit Judge. An appeal was taken to the Supreme Court of the state of Michigan, where the case finally reached a hearing on July 13, 1908, the judgment of the Circuit Court being confirmed.

As soon as possible necessary legal steps were taken to appeal the case to the United States Supreme Court. There the case rests and probably will be heard in the spring of 1910.

Arguments on both sides are voluminous, but they can be boiled down and stated briefly as follows:

The Hydraulic Company claims:

First: No notice was given to the Hydraulic Company prior to the passage of the annulling act.

Second: That the matter is not a local matter but a valid legal contract between the state of Michigan and the Hydraulic Company, and that the passage of the bill was brought about by the Kent County members stating, that they were a unit for it, and representing that it was a local matter, and one that did not involve or interest the representatives other than Kent county.

Third: That the city at whose instigation the proceedings were begun, began proceedings for the purpose of eventually benefitting themselves by getting possession of the Hydraulic Company's property.

Fourth: That the interest of bondholders representing $680,-

000 outstanding bonds and accrued interest had not been considered, although these bondholders are secured by a trust mortgage, which covers not alone the property, but also the franchise of the company.

Fifth: That the reserve clause in the charter permitting future legislatures to repeal or amend the act, did not give this power to amend or repeal for pleasure, but simply repeal or amend for cause.

Sixth: That the repealing acts are void for the following reasons:

A. They are in conflict with section 10 of article 1, of the Constitution of the United States, which prohibits the impairing of the obligations of contracts.

B. They are in conflict with the Fourteenth Amendment of the Constitution, prohibiting the taking of property without due process of law.

C. They are in conflict with section 16 of article 15 of the Michigan State Constitution, that notice shall be given to the directors of a company of any proposed alteration to its charter, which notice should have been given according to act No. 117 of the laws of 1851.

D. They are in conflict with the Michigan State Constitution prohibiting the impairment of the obligations of contract.

E. They are invalid and in conflict with the Michigan State Constitution, prohibiting the taking of private property without due process of law.

F. They conflict with the Michigan State Constitution providing that private property cannot be taken for public uses, unless the necessity is determined by a jury. (Condemnation proceedings.)

G. They are invalid in that the legislature in passing them did not act in good faith nor exercise its discretion at all, but acted arbitrarily and unreasonably without a hearing and without process.

H. They are declared passed without the real assent of the members elect to each house, as the members thought they were voting on local measures.

I. They are invalid in enforcing at the instance of relators for the benefit of the city of Grand Rapids, having been passed at the instance of the city of Grand Rapids for its pecuniary advantage, without the members or directors of the Grand Rapids Hydraulic Company having reasonable notice thereof, or opportunity to be heard.

The arguments set up by the city are briefly as follows:

First: That the bondholders of the Grand Rapids Hydraulic Company are not before the court, and cannot be made parties thereto.

Second: That the legislature had absolute power to act, based on the reserve clause in the charter.

Third: That the legislative journals are conclusive, the only legitimate evidence of action taken by the legislature.

Fourth: That the rule of all pre-requisitions are presumed unless there is a provision that carries proof of notice, and in this case notice of the passage of these acts was presumed.

Fifth: That there is no impairment of contract rights as one legislature cannot bind a future legislature.

Sixth: That the respondents claim of the city benefitting under the annulment act is a new application of the doctrine of estoppel. As a matter of fact the proceedings are in the name of the attorney general of state and not in the city of Grand Rapids.

In reference to the rights of the bondholders, the State Supreme Court ruled as follows:

> These holders of bonds are members of the corporation who are secured by mortgages upon the corporate property franchise.
>
> We deem it sufficient to say that the franchises mortgaged to secure these bonds were no other than those granted to the corporation. Neither did the mortgage in any way change the effect or lessen the right of the legislature to repeal it at any time. The bond holders acquired no greater rights than the corporation had. The existence of the bonds secured by the mortgage is therefore an entirely immaterial circumstance, and in no way affects the correctness of the foregoing reasoning.

In reference to the compensation for the company as provided by the legislative acts, the State Supreme Court stated as follows:

> It is sufficient to say that this provision is not compulsory. It has no force unless the corporation chooses to accept it. If the corporation does accept it voluntarily sells its property on the terms stated, in said provision.

In appealing to the United States Supreme Court, the points on which the appeal was based are the following federal questions:

First: That no state shall pass a law impairing the obligations of contract.

Second: That no one shall be deprived of property, without due process of law.

Recently owing to the failure of the State Supreme Court to grant a proper stay to the company pending the decision of the United States Supreme Court, application for a supersedeas was made by the Hydraulic Company to the United States Supreme Court. A temporary injunction was granted by the United States Supreme Court, which was to act as a stay pending the argument on the supersedeas. The final ruling on the supersedeas was as follows:

> Application denied without prejudice to a renewal thereof pending a change of status.

This interpreted by counsel and authorities in Washington simply means, that inasmuch as the city has not as yet interfered with the Hydraulic Company there is no need of a supersedeas, but if there is a change of status brought about by the city interfering with it in the usual operation of its system the company is invited to again return to the Supreme Court to renew its application for a permanent injunction or supersedeas.

DISCUSSION

President French: As the paper by Mr. Salmon is on lines such that a discussion of it might very well be taken up in connection with the discussion of Mr. Fitzpatrick's paper, we will postpone the discussion of the paper by Mr. Fitzpatrick until we have heard the other paper.

Mr. Jas. R. Fitzpatrick: Mr. President, the situation at Grand Rapids today is as follows: The Grand Rapids Hydraulic Company is a small water works. We have a total pumping capacity of 4,000,000 gallons. Our force main is only twelve inch. We have about twenty miles of mains, and a good standpipe. The distribution system is mainly in the business section, although we have a considerable part in the Hill District.

The city also has its water works, with, I believe, about one-hundred and forty miles of mains, if not a little more. Its pipes parallel ours the entire distance except in two or three small streets where we are the only water supply in the street. We furnish a ground water supply, which we collect, as I described yesterday, through collecting galleries of twenty inch tile pipe running through gravel. The city supplies river water direct without any sedimentation or filtration except that it has a small settling basin for the low service.

In this paper my endeavor has been to be unbiased, and I am going to endeavor to give as much of the other side of the case as I am of our side. I do not want you to believe in starting out that I am in a prejudiced frame of mind.

All our legal arguments have been based on federal law and federal practice.

TESTS AND NOTES ON METHOD OF OPERATION OF A PRODUCER GAS PUMPING PLANT

JAMES R. FITZPATRICK

The Grand Rapids Hydraulic Company has had experience with gas producers and gas engines since November 1, 1906. The plant was installed at various times during the preceding six months, so that on that date it consisted of two complete units, each unit comprising a producer, an engine and a double stage centrifugal pump, belt driven from gas engine.

The first plant consisted of two seventy-horse power suction gas producers, two sixty horsepower engines, and two double stage centrifugal pumps. The engines were 15¾ x 28 inches with a maximum horsepower of about seventy, when running at one hundred and ninety revolutions per minute. The producers had twenty-six inch circular grates. The pumps were six inch discharge, and were rated at one million gallons per day of twenty-four hours against two hundred feet head.

It soon became apparent that the Hydraulic Company was in possession of producers that were too small for engines, that were too small for pumps, that were too small for its business. With this unhappy combination naturally considerable trouble was experienced.

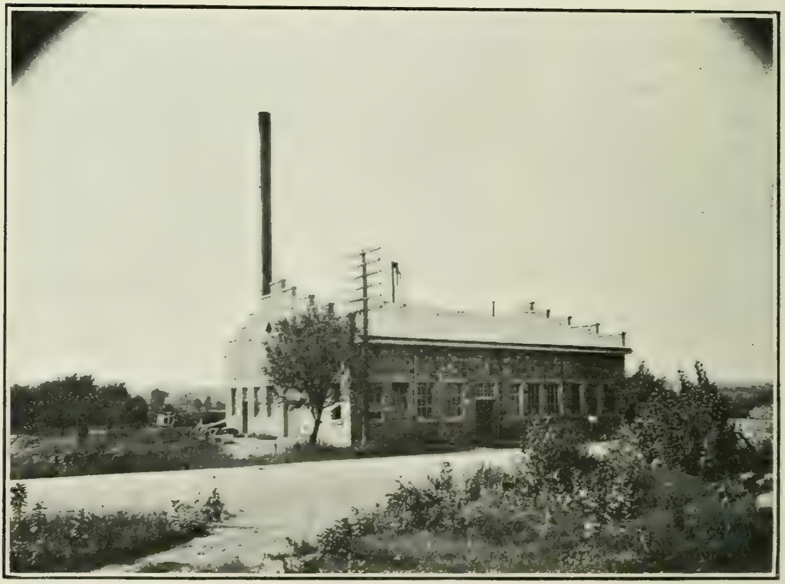
In remedying the trouble the company started at the producers, adding a large producer with forty-six inch circular grate in April, 1907.

Finally it was deemed best to replace the original plant in its entirety with a larger plant. The contract was let during 1908, and called for one additional producer of forty-six inch circular grate, two one hundred horsepower engines, and two triple stage centrifugal pumps. In December, 1908, it was decided to change the type of pumps, and instead of buying centrifugal pumps, the contract was let for two triplex pumps. All of the new machinery was finally installed during March, 1909. Full value of the old plant was allowed by the contractors, when the new plant was purchased.

General Operation of Plant

It is assumed that the gentlemen present are familiar with the operation of a gas producer plant, as the same was clearly brought out at recent conventions of this Association. However, briefly, the operation is as follows:

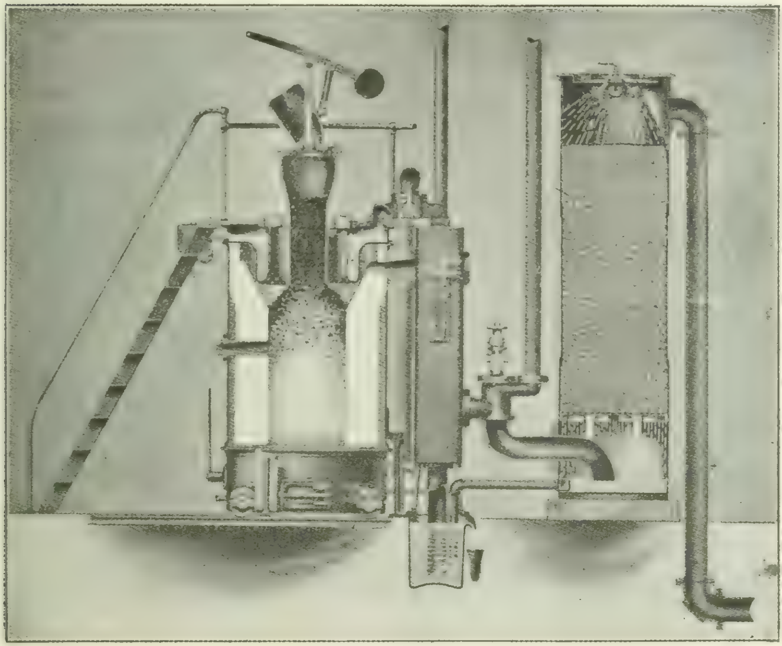
Anthracite coal of pea size is used, and the fire blown by one of the blowers, until such time as the gas tests out at the various test cocks as being suitable. The products of combustion while making gas escape to the atmosphere through a pipe, no stack being necessary.



PUMPING STATION.

As soon as there is suitable gas at the engine test cock, the blower is stopped, the plant then being ready for operation, provided you have sufficient air on hand. Manufacturers state in their catalogues that ninety pounds is sufficient, but experience shows one hundred and forty to be nearer the figure. The suction stroke of the engine is the only draught for the producer; this draws air and steam through the producer, the steam being furnished by the vaporizer, the air through a pipe leading to the grate. The result is the formation of gas containing carbon monoxide, carbon dioxide, nitrogen, hydrogen, marsh gas, etc. The carbon monoxide and hydrogen are what is wanted.

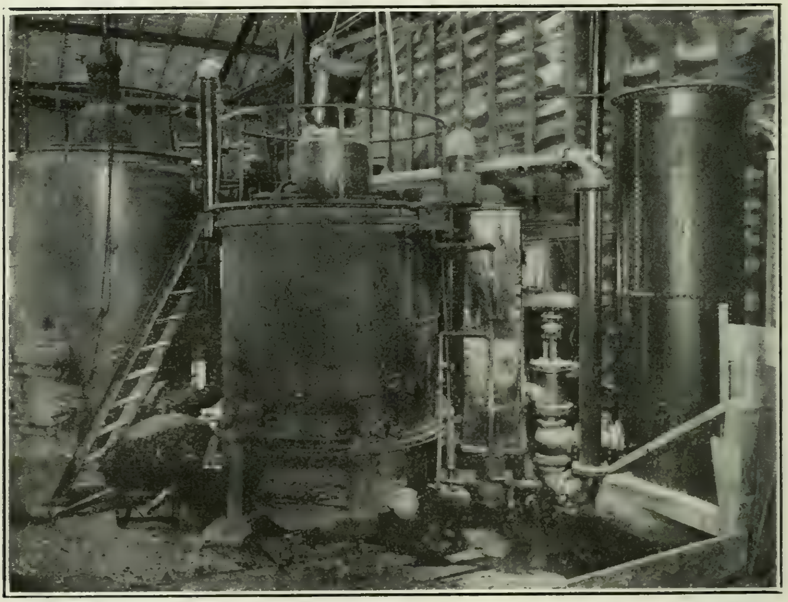
These gases pass through the producer to the scrubber, entering the scrubber at the bottom. The scrubber is filled with coke, a water spray being attached at the top, so that the gas comes in contact with water and coke, which tends to purify it, withholding any particles of carbon that may come over from the producer. The gas goes from the top of the wet scrubber direct to a tank near the engine, or, in some cases, it first passes through the dry scrubber, a low tank in which there are several trays containing excelsior, corn cobs, saw dust, or some other constituent that tends to dry the gas and withhold any impurities that may pass through the wet scrubber.



SECTION OF PRODUCER, SUPERHEATER, AND WET SCRUBBER.

It is the endeavor to furnish, as near as possible, a practical paper rather than a scientific one, and for that reason the manner in which the Hydraulic Company operates its plant will be given.

Anthracite pea coal, Pennsylvania coal, known on the market as Cross Creek, which is purchased through local dealers, is used. This coal, though comparatively clean and free from slate is screened again before being used in the producer. The producer is fed every second hour, but poked once every twenty-four to forty-eight hours, opening the grate doors to do this. The plant is operated continuously twenty-four hours per day and Sunday, using one unit. Whenever necessary, in order to maintain the pressure, the second engine and pump are put in operation. Both engines operate off either producer for a short time, although it is more satisfactory to have both producers in commission when running both engines. The plant is ar-



PRODUCER ROOM.

ranged so that either producer can operate either or both engines through either or both scrubbers.

In starting the engine it is aimed to have one hundred and forty pounds pressure in the air tank, and a hot spark plug. The first impulse is given with air, and at the proper cycle, generally a second shot is given, simply as a precaution. Invariably there is a successful start the first time by doing this. In starting, the ash bed doors of the producer are left open. This is done to prevent a blow-back which would follow in case the inlet valve were held open by a piece of carbon. The cylinder is oiled by means of a pump, while all other bearings are properly oiled, either by cups or running through oil wells.

Once the engine is in operation the operator has to take the usual precautions of examining all oil cups, bearings and cooling devices. The engines are so arranged that they can be speeded or slowed while in operation, this being done by means of a heavy spring of considerable tension, which is used to throttle or open the governor valve.

No friction clutch is used on the pumps. Each pump is equipped on the discharge side with an air chamber,a ten inch check valve and a ten inch gate valve. The discharge and suctions are connected up by two six inch by-pass lines, on which are located a six inch discharge screw and yoke by-pass valve and a six inch relief valve. The six inch relief valve works automatically, blowing off when the pressure is ninety-five pounds. There is a vacuum chamber on the suction side. The by-pass is used in place of a friction clutch in starting the pump. When an engine is started the force main pressure is withheld from the pump by the check valve. Before starting the six inch relief valve is opened wide. The suction line is primed through a two inch line, there being a twelve inch foot valve on each suction line. As soon as the engine is up to speed the pump raises the pressure, the check valve opens, and at this time the operator closes the six inch by-pass valve. It takes about five minutes for the engine to get up to its proper speed, and the pump to begin pumping water.

Past Experience

LABOR

A great source of trouble is inability to get the proper men as operators. The company has had all told, in various capacities in the plant, for the past two and one-half years over twenty-four different men on the pay roll. It has been a case of "hire and fire," until it managed to get the present force together, all of whom have been with it, with one exception, more than a year.

Usually a man who had any knowledge of an automobile or a gasoline engine, would represent himself as a gas engine operator, and in nearly all cases demanded wages far and above those paid to steam men, for the same class of work. Men with six weeks' experience operating gas engines, demanded $90 per month, and got it (for a short time), as for a while the company was completely at the mercy of this class of labor. The labor condition has improved considerably, so that now it is not as hard a proposition to get experienced men.

SALVAGE

Salvage is an absolute necessity in order to fulfill guarantees, where the producer operating is small. The twenty-six inch producers were poked and cleaned through open doors every hour. There was in consequence a large loss of good coal fire, which after cooling was screened, and put back in the producer. The large producers are poked so seldom that there is little or no coal salvage, as all of the product removed from the producer is in the form of ash, excepting when a fire is pulled when a quantity of good coal is obtained from the hot contents.

POKE HOLES

When the present large producers were first installed they were equipped with poke holes at various elevations around the circumference. They also had four poke holes at a level with the grate, past experience having shown that it is easier to clean at short intervals, through small poke holes, than it is to open the large doors. As things now are, these poke holes are not used at all, excepting occasionally to examine the interior of the producer, to see at what point the fire is.

Each producer is equipped with poke holes at the top for cleaning the sides of the interior brick work in the producer. Experience has demonstrated that it is well if your producer is of sufficient capacity, to leave the producer absolutely alone, excepting to add coal when needed, and to poke the fire as little as possible. The top poke holes are used now only when cleaning a cold producer.

VAPORIZERS

The No. 8 producer is provided with a steel water pan on top instead of a separate vaporizer. The No. 7 producer has a separate vaporizer. The steel vaporizer on No. 8 has given excellent satisfaction, and furnishes steam in sufficient quantities to make good gas. In the vaporizer of No. 7, which is modeled like a water tube boiler, the tubes have been replaced once in eighteen months, the same having been eaten away by the gas. The reason, given by the manufacturer for abandoning the separate vaporizer, is that it steams slower. The separate vaporizer seems to be in need of repair oftener than the superimposed vaporizer.

DRY SCRUBBERS

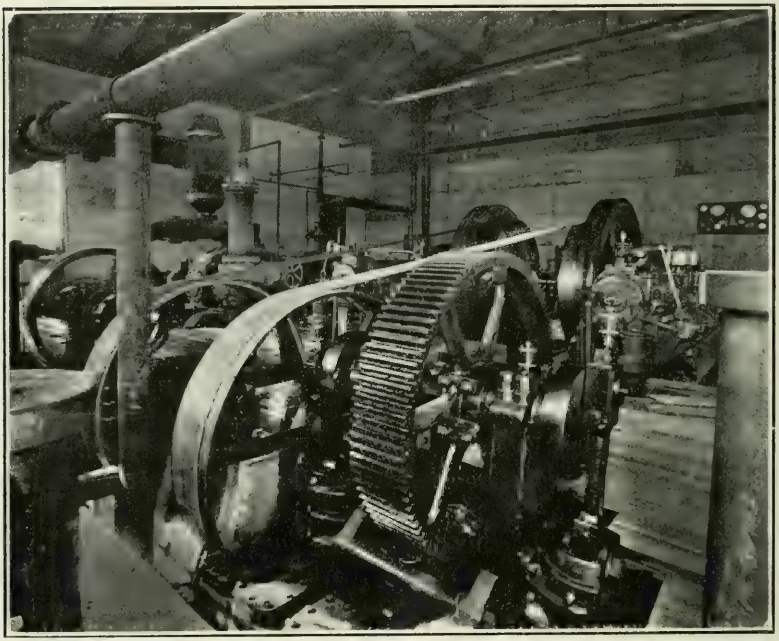
The dry scrubbers have been abandoned, their presence having caused the engines to work harder. By screening the coal in advance the dry scrubber's use was nullified. The dry scrubber, unless absolutely air tight, interferes with the operation of the engine, and is the one dangerous point in the system, where there is a possibility of an explosion. By doing away with the dry scrubber, the operator is able to use more air in his mixture of gas and air at the engine.

CYLINDER HEADS

The cylinder heads are water cooled. The water used is not a soft water, and for that reason it is allowed to run more freely, so as to do away with the possibility of plugging a valve.

GRATES

The grates in small producers have a tendency to burn out quickly. The company found it necessary to renew the grates in both small producers twice. This condition is absent in the large producers, one of which has been in operation, more or less since 1907.



INTERIOR OF ENGINE AND PUMP ROOM.

REPAIRS

In a general way the repairs on the producer are very slight. Barring the possibility of grate renewals and renewal of fire door liners, there is little or nothing to be provided for. In the event that the operator allows his fire to get too near the top some trouble may be experienced. The top might possibly crack, or rivets might be burned sufficiently to permit of air leaks at the top of the producer. Under these conditions it is impossible to get gas of the proper quality.

NECESSARY EXTRAS

It is always well to have on hand, one each of the following: Spark plugs, trip rods, magnetos, a quantity of mica washers for insulation in the spark plug, extra springs necessary in connecting up the ignition mechanism. An extra crank pin box is also a convenience. An extra valve for the gas cock should be kept on hand.

RELIABILITY

Since the new plant was put in operation March 29, 1909, there have been two shut-downs. In the first case the producer failed suddenly. This was due no doubt to inexperience. The producer had been running for more than a week. The second shut-down was due to the short circuiting of a spark plug. The operator noticed that one engine showed considerable "pounding" in the crank shaft, and deciding to take it up immediately put his second engine in operation, after which he shut down the first, and took the crank shaft box off, for the purpose of making the proper adjustment. While this engine was dismantled, the second engine began to give trouble. The trouble was a new one to the operator, and before he discovered just what the source of the annoyance was, the engine "died." Later he discovered the source of the trouble. Since May 6 there have been no shut-downs of any kind, and the plant has been giving excellent satisfaction.

SIZE OF PRODUCER

Having had experience with three types and sizes of producers, the company is convinced that surplus producer capacity is an advantage and a good fault. The producer capacity should be at least 50 to 75 per cent beyond your needs, in which case there should be very little trouble in operation.

CHANGES

Plans have been made to install a 5 feet x 36 inch air tank, and a 3 x 4 double air compressor; these with an extra blower and an extra gasoline engine, make two complete starting devices. The main bearings are extended so that wood split pulleys can be attached. Later the compressor and blower can be operated from a countershaft direct by engine power, instead of by a gasoline engine. A coal hoist, which will permit each producer to be coaled automatically will be installed. A small machine shop is connected with the plant, the power now being furnished by a gasoline engine. The power for this will be also taken from the engine drive.

Pumping Conditions

The Hydraulic Company has a spring water supply collected by a gallery system and carried to a central suction well through twenty-five hundred feet of twenty-inch tile line with open joints. This tile line runs through gravel and clay, the joints of course being closed where the line passes through the clay. The suction well is brick, built on an iron shoe, and is twenty feet in diameter and twenty feet deep. The well is one hundred twenty-five feet from the pumping station.

There are three twelve-inch suction lines and one eight inch line running to the pumping station. The eight-inch line is not now in commission, having been formerly used with one of the centrifugal pumps. Two of the triplex pumps are connected each to a twelve-inch line, and a Blake compound duplex steam pump of one and one-half million gallons capacity is connected to the other twelve-inch line. There is also a two million gallon Deane compound condensing duplex steam pump which can be used, getting its supply from one of the twelve-inch suctions that is connected to one of the Deane triplex pumps. The pumps discharge into the twelve-inch force main direct into the system. There is a standpipe located three miles from the plant, which is used as a storage for any surplus. The average pressure maintained is ninety pounds, excepting during the summer months, when it is ninety-five to one hundred pounds.

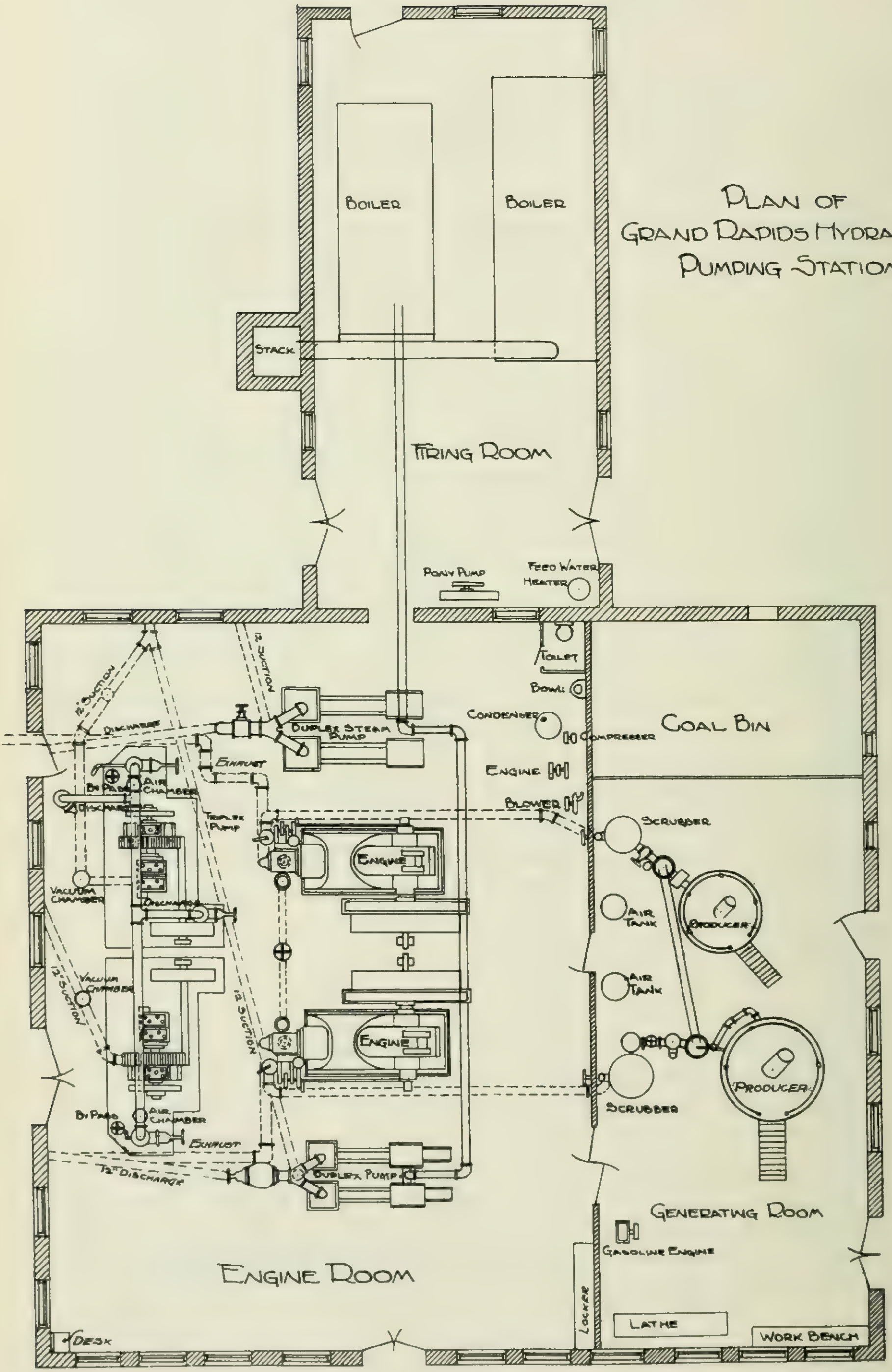
Terms of Contract

The contract between the makers, The Minneapolis Steel and Machinery Co. and the Grand Rapids Hydraulic Company called for the installation of two one hundred horsepower

Muenzel gas engines, one No. 8 Muenzel gas producer having forty-six inch grates (the No. 7 producer had been installed a year previous), two three-stage centrifugal pumps, each with a capacity to pump one million gallons of water in twenty-four hours at gauge pressure of one hundred twenty pounds at the pump. Each engine was guaranteed to be capable of operating to its full capacity each pump. The contractor guaranteed that each engine would deliver one horsepower per hour on one pound of pea anthracite coal on any load between seventy-five and one hundred horsepower, and on one and one-half pounds on any load between fifty and seventy-five horsepower, provided the coal had a calorific value of not less than thirteen thousand five hundred British thermal units. The engines were guaranteed to regulate within two per cent of normal, under all natural changes of load. It was also guaranteed that the banking of the fire should not require more than twenty pounds of coal per hour. The No. 8 producer was guaranteed to be equal in capacity, workmanship and material to the No. 7 producer, purchased in January, 1907. The usual guarantee for one year as to workmanship and material was given. The contractor was relieved of the pump guarantee when it was decided to install triplex pumps instead of triple stage centrifugal pumps. The pumps were guaranteed by the manufacturer, the Deane Steam Pump Company, to deliver eleven hundred eighty-four gallons per minute against one hundred pounds pressure, at forty revolutions per minute. An efficiency guarantee of seventy-eight per cent was made, also the usual guarantees as to workmanship and material.

TEST CONDITIONS

The object of the test was to determine if all these guarantees had been fulfilled; also to determine the general efficiency of the plant. The producers are known as the No. 7 and No. 8 Muenzel producers. Both producers have the same size grate area, forty-six inches in diameter, but the No. 7 producer has a fifty-six inch firepot, and the No. 8 a forty-eight inch firepot. The No. 7 producer's over all diameter is six feet six inches, and the No. 8 is five feet ten inches. The No. 7 producer is ten feet three inches high, and the No. 8 is seven feet six inches



The No. 7 producer has a separate vaporizer, and the No. 8 has a superimposed vaporizer. The No. 8 producer has a removable grate platform, the grate platform and ash pit sliding out on rails. The No. 7 producer has not this arrangement, consisting of one complete shell.

Only wet scrubbers are installed, they being cylindrical steel shells, each three feet in diameter, and ten feet high. The starting devices consist of a type A Olds gasoline engine, two and one-half horse power, a blower, and a single cylinder air compressor, the air storage tank being twenty-four inches by five feet.

The engines are the Muenzel, single cylinder, four cycle with eighteen three-fourth inch cylinder and twenty-eight inch stroke. One engine is right, the other left hand. Each engine is guaranteed to be one hundred horsepower capacity, at one hundred ninety revolutions per minute.

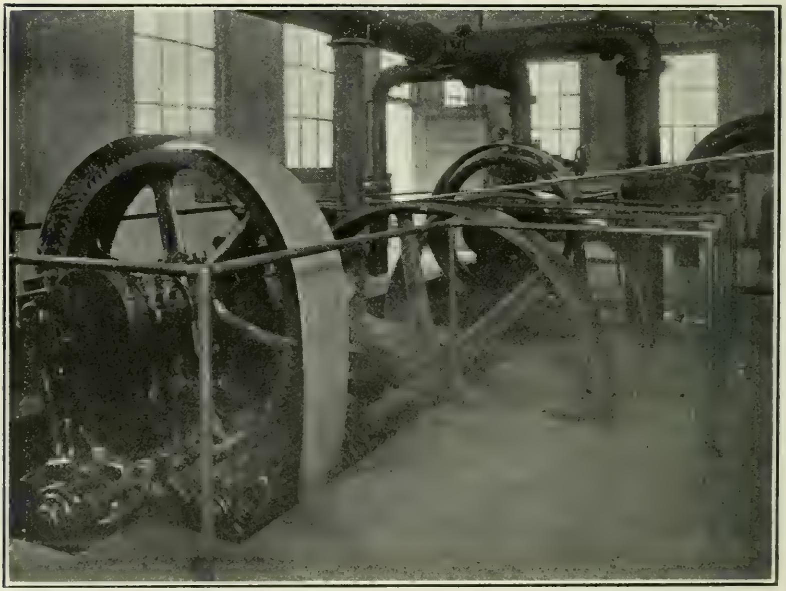
The pumps are the vertical, double acting, triplex pumps of the Deane type, one right and one left hand. Each has a twelve inch stroke, and eleven inch cylinder. The pumps are belt driven from the engines, the belts being fourteen inch double, extra heavy stock, running thirty to thirty-three ounces to the foot, and are made of short lap oak tanned leather. The gas engine pulleys are eighty-six inches in diameter and the belt pulleys eighty inches. The pumps are geared 4.64 to 1.

The test was conducted on June 1, 2 and 3 by the writer who represented the Grand Rapids Hydraulic Company. Mr. J. J. Wernette, mechanical engineer of Grand Rapids, represented the contractors.

It was the intention to test one of the producers from a cold start, and the second which was in operation at the beginning of the test, was to have been tested from a hot start. However, the producer that was then under fire had been running steadily for eleven days previous, and began to show signs of a deterioration of gas, the engine lagging occasionally. Fearing a possible shut-down in the middle of the test, it was decided to clean this producer also, and test both plants from a cold start.

Being cross connected the conditions at the time of the start, necessitated running No. 1 engine from No. 2 producer. Upon completion of the twenty-four hour run, No. 1 producer was put in operation and furnished the gas to drive No. 2 pump.

As the test was made under working conditions, and as it is required to operate twenty-four hours daily, the brake horsepower could not be obtained. An engine efficiency of 85 per cent was assumed. This efficiency was obtained by a shop test before engines were delivered. The test was made by firing each producer in turn, running each approximately twenty-four hours, pulling the fire and weighing the salvage. The No. 2 producer was given two runs, one of approximately twenty-four hours and one of about three hours. Between these runs the producer was banked. This was done to make a bank test.



CLOSE VIEW OF PUMPS. FARTHER PUMP IN OPERATION.

It was impossible to determine the slip of the pumps. The pumps are new and have been in operation but two months. A close examination failed to show any great slippage, so the slippage of pumps was assumed at 5 per cent, which is probably an outside figure. The standpipe is several miles away from the pumps, the system being direct pumping, with the standpipe to take care of the surplus, so that pumping into the standpipe would not give any correct indication, inasmuch as there are many heavy users on the main line, before it reaches the standpipe.

The gauges, meters and scales used during the test were tested and found to be correct. In determining standby loss, the No. 2 producer after completing its first run was thoroughly shaken, the lower doors opened at the grate, and all ash and clinker removed, that could be. The height of coal above grate was then measured. The producer was allowed to stand, all doors and poke holes being closed tight, and no coal added for twenty hours at which time the producer was again thoroughly shaken down, and the height above grate measured. The difference was two inches, and knowing the interior diameter of the firepot the cubical contents were determined. This two inches of coal burned was considered as dry partially burned coal.

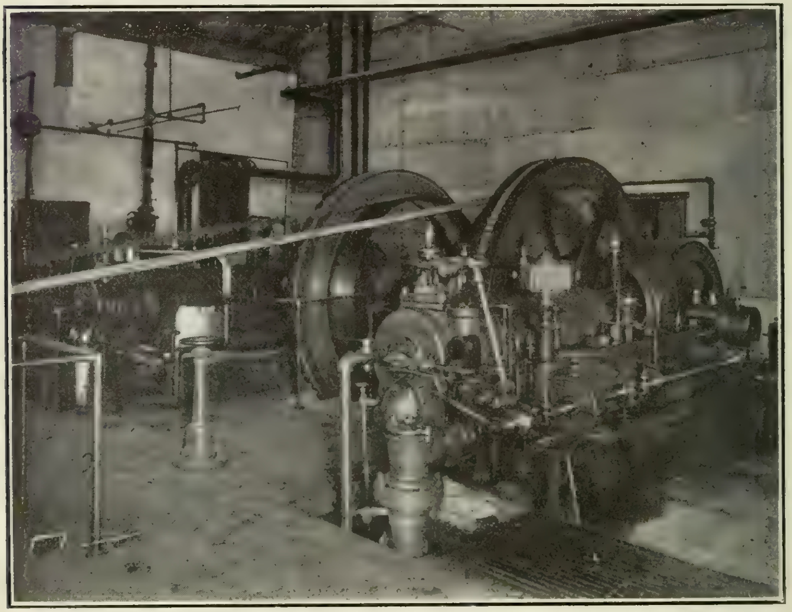
A determination was made to get at the difference in weight between a cubic foot of dry unburned coal, dry partially burned coal, and wet partially burned coal. It was found that the wet coal weighed 8.3 per cent more than the dry partially burned coal, the dry partially burned coal weighing 3.3 per cent less than the unburned coal. For making this determination the net value of the salvage, considered as good coal, was determined.

After each producer had made its run the fire was pulled, no account being taken of the ash, to determine the value of the salvage, meaning the coal that we can again use in the producer. As soon as the fire was pulled the hot coal was thoroughly wet down.

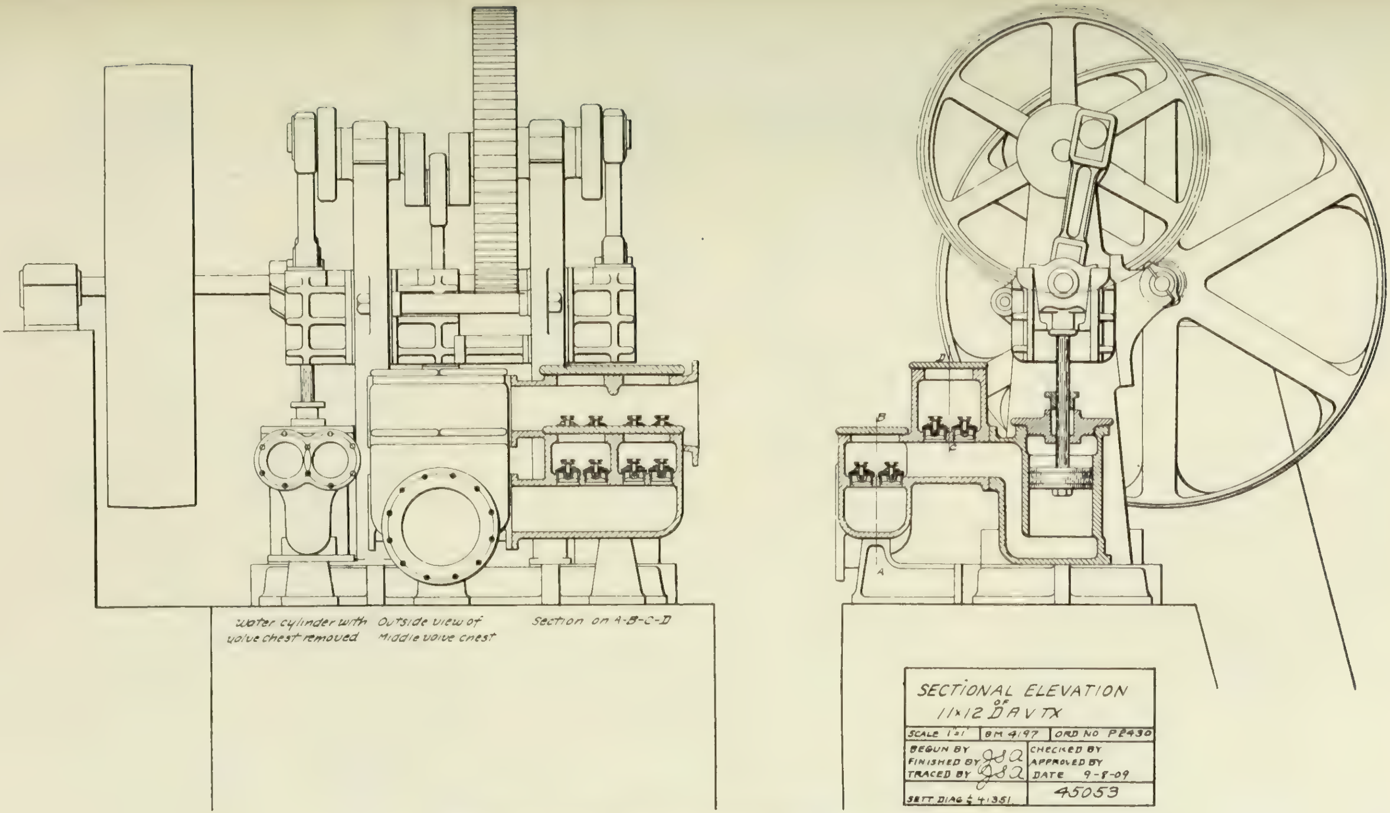
No. 1 pump when put in operation caught its prime, and started pumping water in five minutes. No. 2 pump did the same thing in four minutes. The tests were considered to have begun at the time the pumps started doing work. The time the engines were running light was considered as standby loss. It was necessary to shut down in order to remove the indicator reducing motion from the engine. The reducing motion was removed and the engine put in operation, and the pumps started pumping in seven minutes.

Following the completion of the test on No. 1 producer and the drawing of the fire, the producer was thoroughly cleaned, refilled with coal and put back in operation in three hours and twenty-four minutes. This necessitated the handling of all the salvage and the filling of the producer for the new run with approximately one ton of coal, all of which had to be handled in buckets, carrying eighty pounds each. This is given to give an idea of the time necessary to put a producer of this size in operation.

The revolution counter on pump No. 2 got out of order during the middle of the run. However, careful determinations had been made of the revolutions per minute of the engine, the pump pulley and the pump crank. From these readings an average of the revolutions per minute of the pump was obtained. We had an accurate determination of the revolutions per minute of pump No. 1, and pump No. 2 was found to be within .6 of a stroke per minute the same as pump No. 1. A comparison of the revolutions per minute of the two pumps during the time that the counter on pump No. 2 was in working order showed that during the corresponding hours pump No .1 was running at a slightly greater speed than pump No. 2. This slightly in-



CLOSE VIEW OF ENGINES. FARTHER ENGINE IN OPERATION.



SECTIONAL ELEVATION OF DEANE TRIPLEX PUMP creased speed of pump No. 1 over pump No. 2 was constant throughout the first twenty-four hours of the test, and for that reason we believe that the final revolutions per minute of pump No. 2, which is slightly under that of pump No. 1 is correct. All readings were taken every thirty minutes except when the counter of pump No. 2 became out of order, after which readings of the revolutions per minute of this pump were taken at fifteen minutes duration. No effort was made to determine the amount of water that the vaporizers and scrubbers used separately.

RESULT OF TEST

The stopping of the revolution counter during the test of one engine was unfortunate, but a careful study of the figures obtained for pump No. 2 will not show much difference from pump No. 1. In reference to the test of pump No. 1 it is known positively the average pressure, the total displacement, and the total coal burned, so that the duty of this unit during the test can be found accurately.

During the month of May a careful record of coal consumed, average pressure and total plunger displacement was kept. During this month the counters were on both pumps and in working order. After allowing for all water used for cooling purposes, 5 per cent slip of pumps, which is probably high as the pumps are new, and based on total coal consumption for the month, the duty figure is within 5.5 per cent of the test duty figure.

During the recent test a total of 3,412,982 gallons, plunger displacement, was pumped against an average dynamic head of 237.29 feet (103 lb.) with a total consumption of coal, including one producer banked for nearly twenty-seven hours, of 4002.4, practically two net tons of pea anthracite coal, at a cost of $3.40 per million gallons. With coal at $6 per net ton, the cost would have been $3.60 per million gallons.

During the month of May there was a total displacement of 50,169,712 gallons against an average dynamic head of 225.23 feet (98 lbs.) with a total coal consumption of 57,196 lbs. slightly more than 28½ tons, at a cost of $6 per ton. This made the cost per million gallons pumped against a head 5 lbs. lower than the test, $3.42.

PRODUCERS

	No. 1	*No. 2*
Length of test, hours and minutes	26 20	54 15
Time operating, hours and minutes	26 20	27 17
Time banked, hours and minutes	00 00	26 58
Coal to start, pounds	1875	1080
Coal added during test, pounds	1440	1680
Total coal used, pounds	3315	2760
Coal banked stand-by losses, pounds	0000	135.6
Coal Salvage gross (wet and partially burned)	1392.50	950.0
Coal Salvage net (dry unburned), pounds	1232.09	840.5
Coal consumed, pounds	2082.91	1783.9
Coal consumed per hour, pounds	79.20	65.50
Coal banked per hour, pounds	00.00	5.03
Coal consumed per hour including banking, pounds	79.20	70.53
Coal consumed, less banking, per square foot of grate, pounds	6.86	5.66
Brake horsepower at engine (efficiency 85%)	71.35	69.22
I. H. P.	84.18*	81.93†
Coal consumed per brake horsepower per hour	1.1	.92
Poked	0.0	(2) before and after banking.
Stoked	Every 2 to 3 hours	Every 2 to 3 hours
Grate diameter	46″	46″
Firepot diameter	56″	48″
Diameter of producer over all	6′ 6″	5′ 10″
Height of producer over all	10′ 3″	7′ 6″
Height grates to gas outlet	6′ 2″	4′ 6″
Vaporizer type	Superimposed and separate	Superimposed
Scrubber diameter	3′	3′
Scrubber height	10′ 6″	10′ 6″
Type producer	Muenzel No. 7	Muenzel No. 8
Rated horsepower	165	150

ENGINES

	No. 1	*No. 2*
Length of test, hours and minutes	24 00	29 37
Time joint operation	2 20	2 20
R. P. M.	157.5	155.7

*Engine No. 1 operated by producer No. 2 during test.
†Engine No. 2 operated by producer No. 1 during test.

	No. 1	*No. 2*
R. P. M. maximum	176.0	170.0
R. P. M. minimum	142.0	138.0
I. H. P. running alone	81.93	84.18
I. H. P. running jointly	102.6	102.6
Friction of engine, per cent	.15	.15
Efficiency of engine, per cent	.85	.85
Brake horsepower	69.22	71.35
Temper of cooling water. Cylinder head, degrees F	106.36	106.36
Temper of cooling water. Jacket, degrees F	112.43	112.43
Cylinder, inches	18¾″	18¾″
Stroke	28	28
Belt pulley diameter	86″	86″

PUMPS

	No. 1.	*No. 2*
Duration of test, hours and minutes	24	29 37
Average gauge pressure when running together	110.02	110.02
Average gauge pressure when running alone	89.51	93.67
Elevation feet	206.65	216.28
Suction lift (including friction)	11.55	11.55
Elevation of gauge above pump	10.55	10.55
Dynamic head	228.75	238.38
Temperature of water pumped degrees F.	51	51
R. P. M. pulley	166.8	164.79
R. P. M. pump	36.184	35.5
Displacement per revolution, gallons	29.62	29.62
Displacement per minute, gallons	1071.84	1051.51
Total revolutions	52106.9	63083.5
Total displacement gallons	1,543,439	1,868,533
Total displacement less slip (5%)	1,466,267	1,775,106
Belt slip	.013	.0158
Slip (assumed, pump new)	.05	.05
Efficiency of pump (less pump and belt slip)	.86	.86
Length of suction, feet	125	110
Stroke	12″	12″
Diameter of cylinders	11″	11″
Pump pulley	80″	80″
Ratio gearing	4.64	4.64
Ratio engine pulley to pump pulley	1.075	1.075

MISCELLANEOUS

Water for vaporizer, scrubbers, cooling engines—per minute, cubic feet	2.005
Total water consumed during test	6540 cu. ft.
Oil per day, 24 hours, average	2½ gallons
Coal analysis	
Moisture	1.73
Volatile carbons	7.00
Fixed carbons	76.76
Ash	16.24
Sulphur	.506
B. t. u.	12730

PLANT COMBINED

Average G. P. M	1060.7
Average G. P. M. cooling water	14.997
Average gauge pressure, pounds	93.2
Average gauge pressure, feet	215.19
Suction, feet	11.55
Gauge elevation, feet	10.55
Dynamic head, feet	237.29
Total coal consumed, pounds (less banking)	3866.8
Total coal consumed, pounds (with banking)	4002.4
Coal consumed per brake horsepower per hour, (less banking), pounds	1.005
Coal consumed per brake horsepower per hour (with banking), pounds	1.04
Total B. h. p. developed	3,846.9
Duty, less banking, less cooling water, less 5% pump slip	163,535,000

TEST OF PLANT OPERATION, MONTH OF MAY, 1909

Producer operating hours. No. 1, 598; No. 2, 151; total.	749
Engines operating, hours	752.75
Stand-by hours	3.25
Engine r. p. m	169.6
Pump r. p. m. less slip	37.4
Gallons p. m.	1107.79
Total displacement revolutions	1,691,415
Total displacement gallons	50,169,712
Average gauge pressure, pounds	90.6
Average gauge pressure, feet	208.38
Suction, feet	6.3
Gauge height, feet	10.5
Dynamic head, feet	225.23

Average belt slip	.0144
Changed producers	4
I. H. P. (plant efficiency 75.6)	79.2
B. H. P. (94.5)	63.36
B. H. P., hour (80%)	47920
Coal consumed total	57196
Coal consumed per hour	75.9
Coal consumed per B. h. p. per hour	1.19

SUMMARY

	Guarantee	*Test*
Producer operation	1 lb. per h. p. hr.	.9 per B. h. p. hr.
Producer banking	20 lb. per hour	5.03 lb. per hour
Engine h.p.	100 B. h. p. at 190 r.p.m.	95 B. h. p. at 168 r. p. m.
Pump	78 per cent	86 per cent.

DISCUSSION

President French: The very interesting paper of Mr. Fitzpatrick is before us now for discussion. I am sure that Mr. Fitzpatrick will be ready to answer any questions that you may ask in connection with it.

Mr. D. R. Gwinn: I estimate that the cost is about $4 per million gallons. Is that about right?

Mr. J. R. Fitzpatrick: I think so. We hope to get it down to that.

Mr. A. A. Reimer: That cost is only the cost of coal, is it not, with no operating costs included?

Mr. J. R. Fitzpatrick: Yes. Our other plant was a compound condensing steam plant, duplex pumps, with boilers not in very good condition. I have the run for the month of May which shows total operating cost, exclusive of depreciation and interest, but including oil, waste, labor, coal, and all the necessaries that go to keep a plant in operation—total cost was about $100 less than the cost of soft coal alone for the month of March. You will be surprised at the duty that you can develop with a gas plant. You can get a very high duty with a gas producer plant, for a small plant, assuming a comparison between a small steam plant and a small gas producer plant. I guess as you go up into bigger plants with triple expansion steam pumps of around about twelve million or better, the duties are about the same.

MR. D. R. GWINN: Was 156,000,000 your station duty for the month?

MR. J. R. FITZPATRICK: Yes, sir. Every figure that I have got there is averaged. I know that our lift was very light that month. You can see that from the quantity of coal that we burned; $170 will cover all the coal that we bought for that month. It was even smaller than that for the past month, because we are paying so much money for our coal, and they start in at a certain figure at April and keep adding about ten cents a month, so that along in the year about September you are paying $6 a ton, and that continues for the next six or seven months. We have four men, two men each on twelve hour shifts. The plant could be operated with three men if it were located in any other than its present location. It is nearly a half mile from the city line. It is a little dangerous to leave one man there at night. Something might happen, and with high speed machinery it is really necessary to have two men there. So we have to stand for an extra man on our pay roll. If we were nearer the city we might get along without him.

MR. SMITH: How does the installation compare as to cost with a steam plant of the same capacity?

MR. J. R. FITZPATRICK: I think the gas plant is about twenty per cent more in first cost, twenty or twenty-five per cent, that is in small units.

PRESIDENT FRENCH: You are operating this plant with anthracite coal?

MR. J. R. FITZPATRICK: Yes, sir, pea size anthracite coal.

PRESIDENT FRENCH: Could you not use bituminous coal to better advantage?

MR. J. R. FITZPATRICK: Then we would need more purification apparatus.

PRESIDENT FRENCH: Would you get a higher efficiency?

MR. J. R. FITZPATRICK: I suppose so; but it would mean the changing over of our purifying apparatus. I think the Westinghouse people have lately put out a suction gas producer that will operate with bituminous coal. Ours is a suction gas producer.

PRESIDENT FRENCH: If you are to have a continuous service there you are obliged to have two machines, are you not? Could you depend upon one at all?

Mr. J. R. Fitzpatrick: We figure upon shifting machines about every third day, keep shifting back and forth.

President French: Why do you do that, on account of your clinkers?

Mr. J. R. Fitzpatrick: We do not shift the producers, just the engines. We simply think they need rest, that is all.

President French: I did not know but what there was some other reason.

Mr. J. R. Fitzpatrick: No, we think we can keep them in a more uniform condition better by shifting them; it gives us more chance to look after any little repairs that they may need, or anything that may develop. We had centrifugal double stage pumps at first, and we had a terrible time with them. It looked as though we would have to take triple stage pumps in order to get a better adjustment and have everything work out nicely. The first plant was in when I went there. I did not buy the first plant. I say that in justice to myself.

Mr. H. F. Dunham: Can you give us the cost per unit?

Mr. J. R. Fitzpatrick: I would not like to state just how our adjustment was; but they figure now $60 per unit per h.p. for producer and engine.

Mr. D. R. Gwinn: Are they noisy?

Mr. J. R. Fitzpatrick: Very little noise, little if any compared with what we anticipated. We have eighty inch pulleys, with fourteen inch belt, which is more than sufficient for the power we need. It is a good heavy belt. I know the noise is no more than it was with the centrifugal, because the centrifugal pumps were chugging away and raising a ruction all the time. When we ran the centrifugal pumps with the same size engine pulley, we had only a twelve-inch belt. The centrifugal did not maintain its efficiency and was a failure. There were certain times when the lift was a little more than it really ought to have been, and we were satisfied that the pump would not stand up. It started out with a guaranteed efficiency of eighty-five pounds. When the pumps were taken out we were lucky to carry sixty-five pounds on the gage, sixty-five to seventy pounds both running together. Pumps seem to lose their efficiency, that has been my experience.

Mr. W. H. Friedrich: Did your water head go down to your well that you were drawing from, or did you have to lift the water extremely high?

MR. J. R. FITZPATRICK: The pumps themselves do the lifting.

MR. W. H. FRIEDRICH: How many feet from suction of pump to surface of water?

MR. J. R. FITZPATRICK: At that time we were raising sixteen feet.

MR. W. H. FRIEDRICH: A centrifugal pump does not work very satisfactorily at that lift anyway, unless built especially for high lifts.

MR. J. R. FITZPATRICK: I would not exactly condemn the centrifugal pump for every case, but for our particular case it did not fill the bill.

PROF. K. G. SMITH: I have run a 25 h.p. gas engine and we get from 87 to 90 per cent efficiency under brake test and also indicated horsepower. I remember when I started in at one time in my career as a gas engineer with a traction engine, that the traction engine gave 85 per cent efficiency, and that engine was supposed to develop 20 h.p. I have seen a 10 h.p. gasoline engine in first class condition, that gave an efficiency of 91 per cent.

MR. W. H. FRIEDRICH: Has the gas producer plant been in operation long enough to know how long it will last? They are quite expensive to start with. Is it considered that they are reliable, are they something that will run ten or twenty years, or are they all played out in four or five years, so that you have to get a new outfit?

MR. J. R. FITZPATRICK: Of course gas engines have been in operation some of them now for fifteen or twenty years, I think. I see no reason why an engine working on a gas producer should be subjected to any more duty than an engine working on a city supply.

MR. W. H. FRIEDRICH: Does not the efficiency drop very rapidly on a gas producer after it is run a little while?

MR. J. R. FITZPATRICK: I see no reason why it should. To begin with, the producer is a very simple piece of apparatus, there are no moving parts, simply a gas retort; and the idea is to get a certain amount of gas out of it after blowing some steam and air in at the grate. There are no moving parts of any kind. If there were any cast iron parts, as there were in the case of the first producers that they got out, then there would be some heavy renewals; but the present producers are sheet steel from A to Z. One producer we have had since April, 1907. We have had no trouble with the producer itself. We have had some trouble with castings on the outside, and we have had to renew the water tubes; but we have had absolutely no repairs on the producers since April, 1907, excepting heads. The producer was in an imperfect condition when we first got it. But since we have gotten a new type of head on the water tank, nothing has burned out, and it has been subjected to considerable service.

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Mr. Ernest McCullough has resigned as chief engineer of the Northwestern Expanded Metal Co. to become an associate editor of ENGINEERING-CONTRACTING. Mr. McCullough is the well-known author of "Engineering Work in Towns and Cities," "Manual of Reinforced Concrete," "Business of Contracting," "Municipal Public Works," "Engineering Contractors' Pocketbook," etc. He has had a practical experience of 22 years and is generally recognized as one of the world's authorities on matters pertaining to municipal work.

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- Earth and Rock Excavation.
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Mr. Halbert P. Gillette, Managing Editor, was for three years a builder of roads in the State of Washington, for two years Assistant State Engineer of New York and for five years a contractor, before he wrote his practical books whose sales have broken all records for technical books,—"Handbook of Cost Data," "Rock Excavation—Methods and Cost," "Economics of Road Construction," etc. He was recently selected as Chief Engineer of the Washington Railroad Commission, for whom he made a complete valuation of all the railroads in that state amounting to $200,000,000 worth of property.

Mr. Chas. S. Hill, author of "Chicago Main Drainage Canal," joint author with Mr. Halbert P. Gillette of "Concrete Construction—Methods and Cost," etc., was for 18 years on the editorial staff of "Engineering News." Our other associate editors, Mr. C. T. Murray and Mr. F. A. Smith, are also well-known writers, who are familiar with the practical as well as the theoretical side of engineering.

The addition of Mr. McCullough gives ENGINEERING-CONTRACTING the strongest editorial staff of any American engineering journal. The fact that these men know whereof they speak and write is appreciated by the engineering profession and the notes struck in our editorial department will reverberate through the subscription and advertising departments, resulting in more subscribers for our advertisers and more advertisers for our subscribers.

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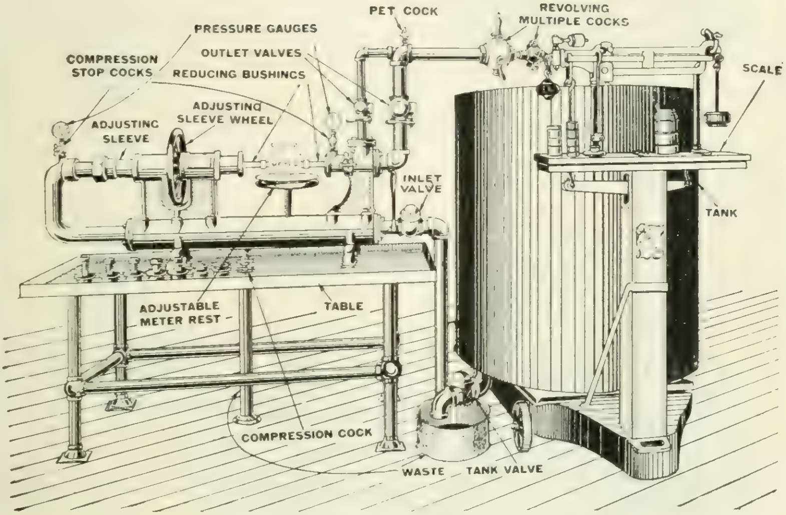

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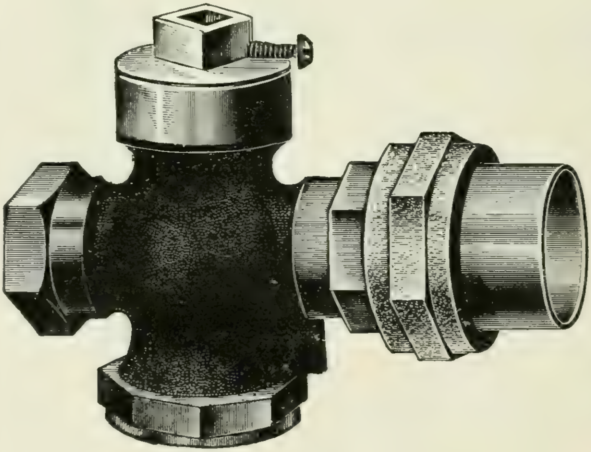

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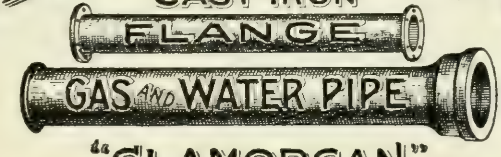

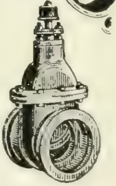

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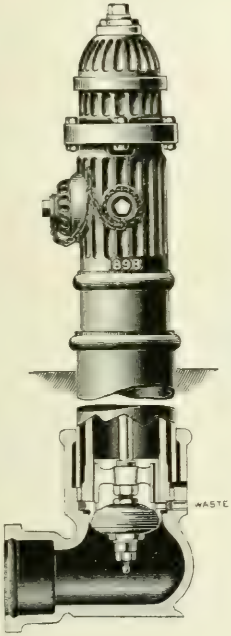

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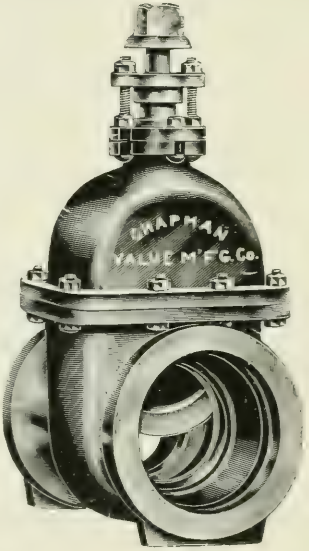

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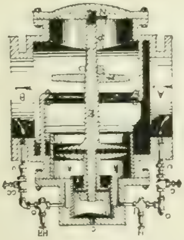

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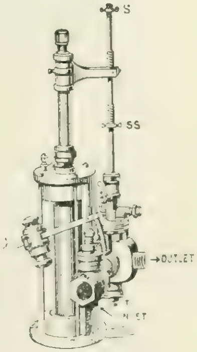

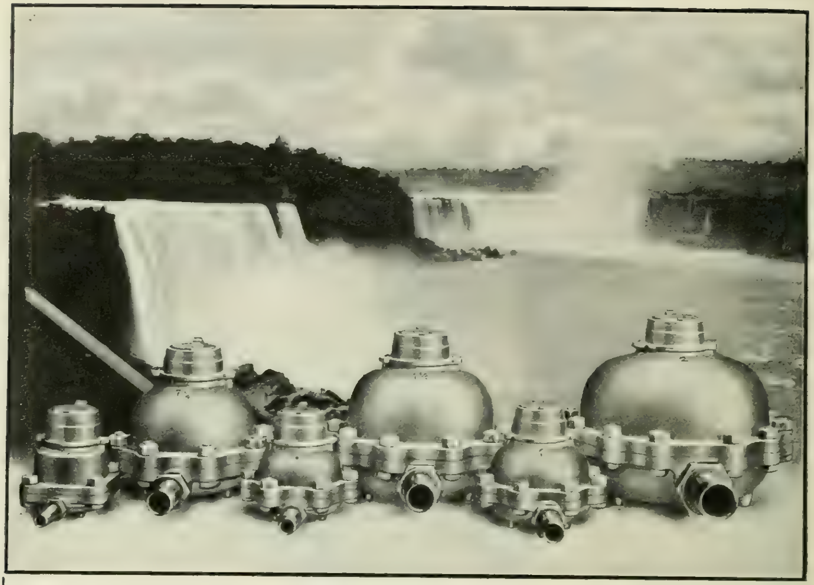

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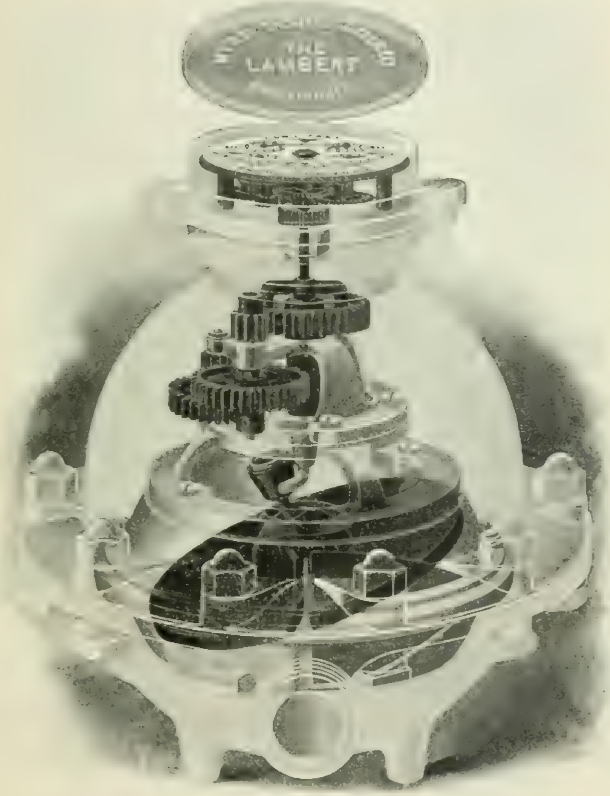

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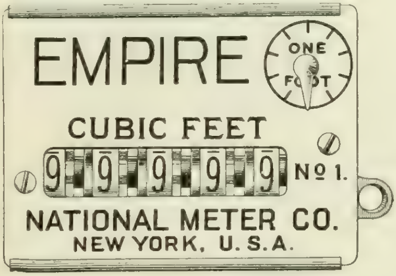

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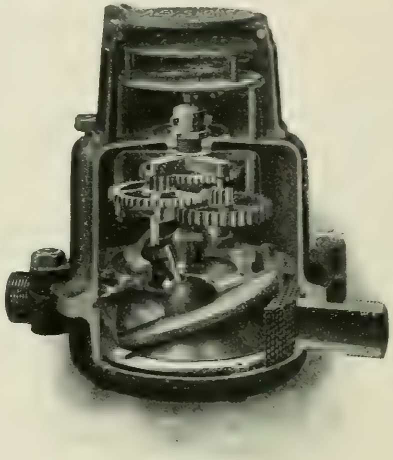

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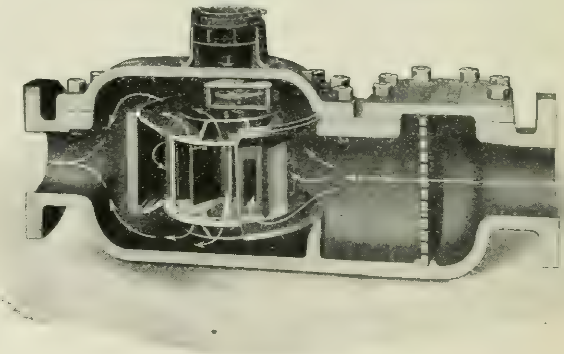

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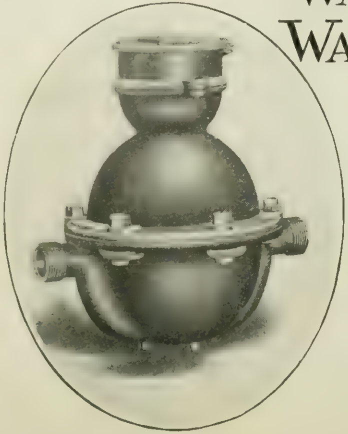

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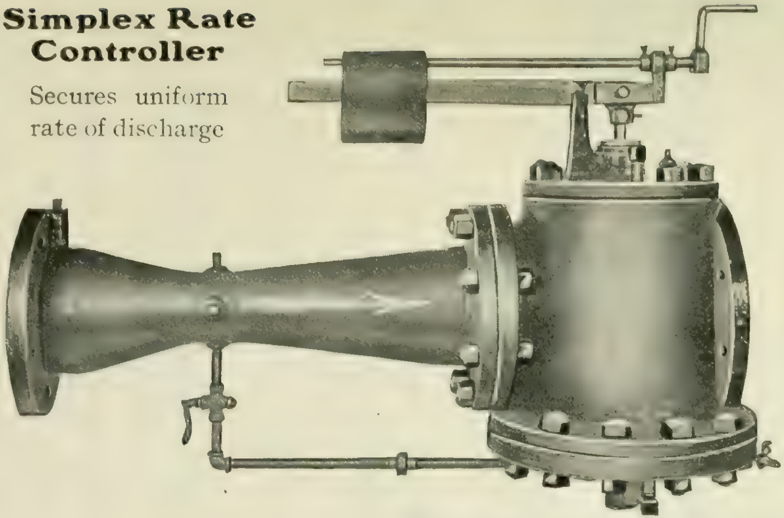

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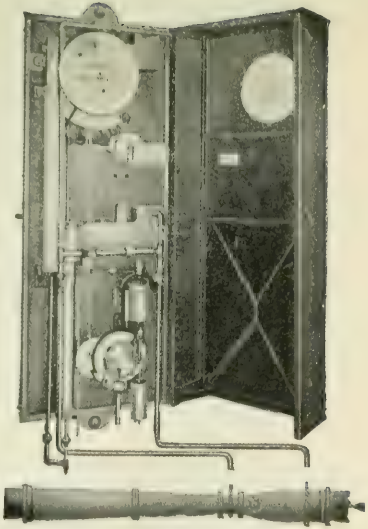

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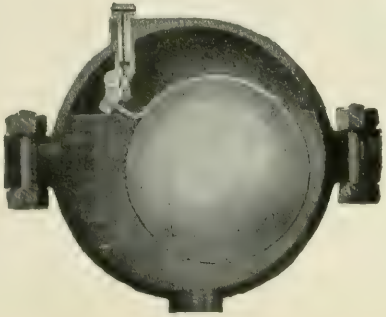

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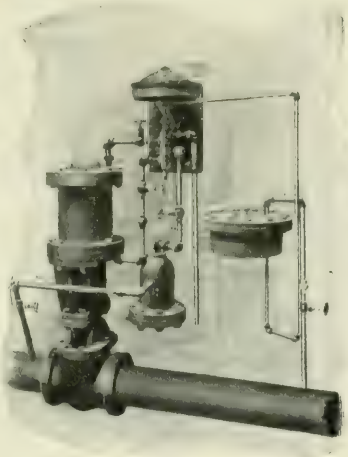

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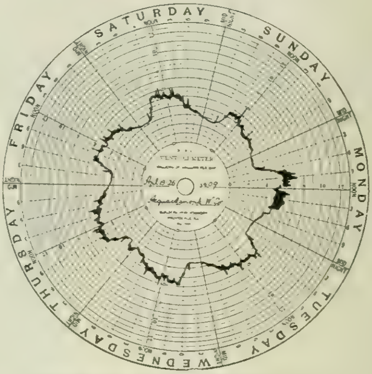

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1902	157.2	187	2028	10.84
1903	243.7	290	2508	8.65

Note: During 1899 and a portion of 1900 a wood tank was being used. This leaked so badly that it was abandoned and the system operated by direct pressure until January, 1902, when a steel tank was put into service.

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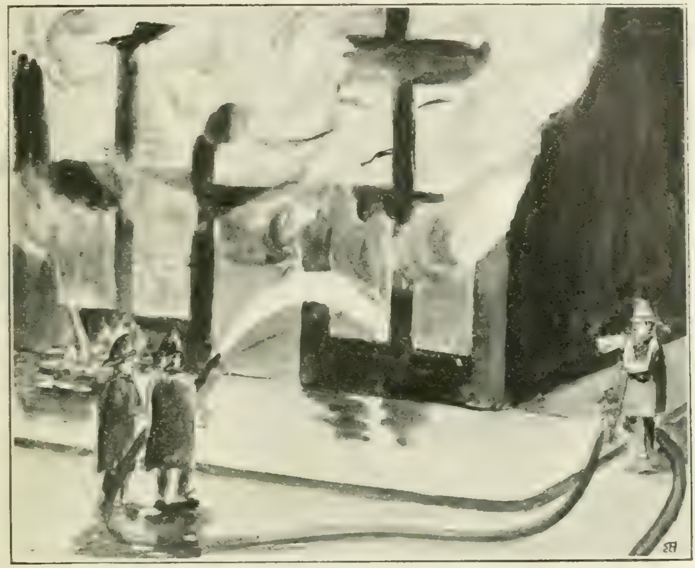

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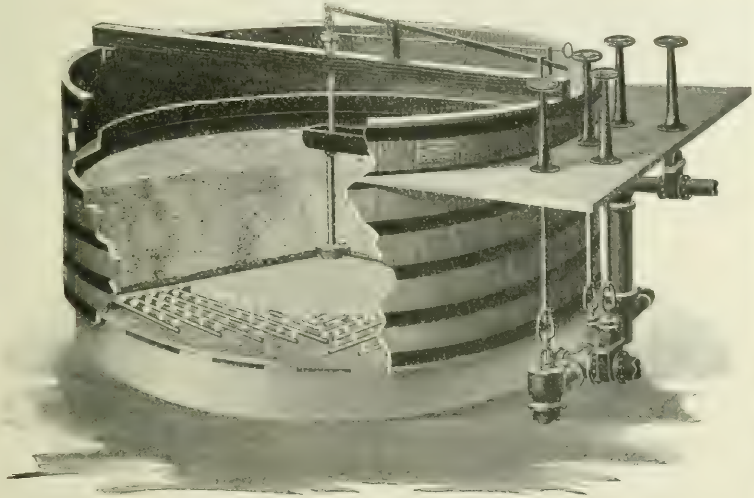

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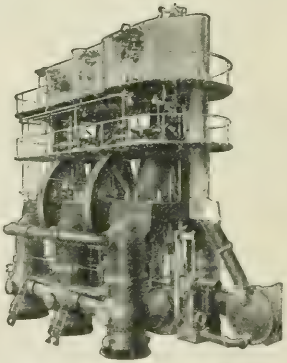

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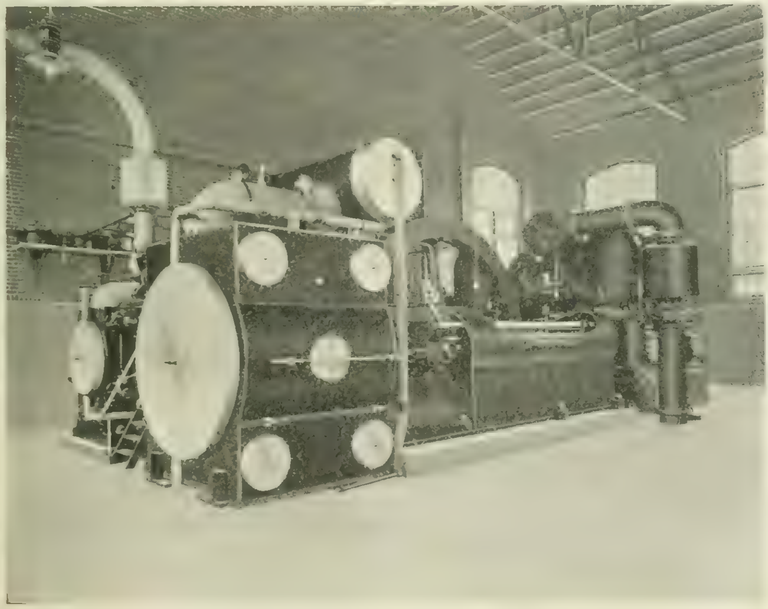

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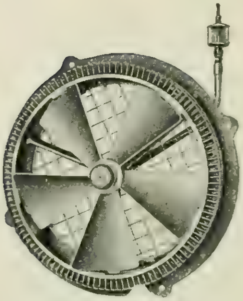

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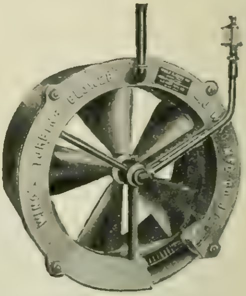

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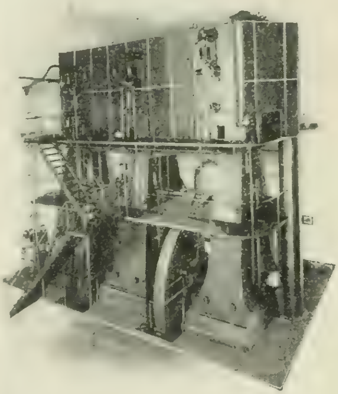

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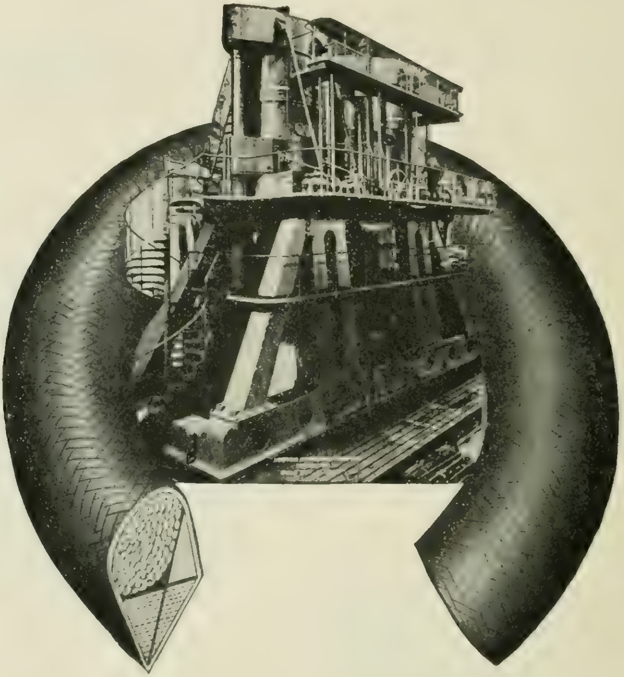

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